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ORIGINAL ARTICLES.

I.—On New Specimens of *Dendrerpeton Acadianum*, with Remarks on other Carboniferous Amphibians.

By Sir J. William Dawson, LL.D., F.R.S., etc.

THE genus *Dendrerpeton* was established by Owen on the evidence of remains found by Sir C. Lyell and the writer in an erect tree at the South Joggins in Nova Scotia in 1852.[1] Other specimens were afterwards obtained, and the most complete, presented by me to the Cabinet of the Geological Society, was found in 1861, and described in my "Airbreathers of the Coal Period."[2] These remains rendered it certain that the animal belongs to the order Labyrinthodontia,[3] and it is regarded by Lydekker as the type of a family in that group.[4]

As the characters of the type-species ascertained by Owen and by the writer have not as yet been stated in connected form, and the genus may in consequence be said to be still imperfectly known, it may be useful to sum them up before proceeding to notice some specimens recently obtained, and which have added somewhat to our knowledge of the type-species.

Dendrerpeton Acadianum, Owen, Journ. Geol. Soc. Lond. vol. ix. 1853.

Skull of moderate size and rounded broadly in front. Nostrils small and near the muzzle. Orbits nearly in the middle of the length. Occipital condyle double. Parietal foramen small. Surface of cranial bones sculptured with relatively deep pits. Teeth conical, smooth above, grooved at base, especially on the inner side; enamel simply plicated at base. Outer series of teeth somewhat unequal and larger anteriorly in the intermaxillary bones. A few large teeth within on the inner surface of the maxillaries. A group of small simple teeth on the vomerine bones. Mandibles sculptured like the skull, but much more feebly. Teeth similar to those in the upper jaw, but not larger in front. For the arrangement of the central cranial bones see diagram in Memoirs on Animal Remains in Erect Trees, Phil. Trans. Royal Society, 1882, pl. 44.

[1] Journ. Geol. Soc. of London, vol. ix. p. 66. A preliminary examination of the specimens had been made by the late Prof. J. Wyman, of Cambridge, U.S., and was quoted by Prof. Owen.

[2] Montreal, 1863. See also Journ. Geol. Soc. vol. xvi. p. 273; vol. xviii. p. 5; and vol. xix. p. 470.

[3] Journ. Geol. Soc. vol. xv. p. 274; also "Airbreathers of the Coal Period."

[4] Brit. Museum Catalogue, Reptiles and Amphibia, vol. iv. p. 170; also Nicholson and Lydekker, Manual of Palæontology, vol. ii. p. 1032.

Vertebræ imperfectly ossified, very slightly biconcave, with large and broad neural processes in dorsal region. Those of the tail have spines above and below. Ribs of moderate length, with expanded head and slight shoulder; solid towards the head, but hollow and thin-walled at distal end, the longest barely equal to the breadth of the skull, curved, the anterior ones very much so, scapular and pelvic bones large and well ossified. Ilium? broad.

Limbs well developed, especially the anterior pair. Limb-bones ossified and cancellated at the extremities, and with bony walls of considerable thickness. Humerus equal to more than half of the length of the mandible. Femur smaller than humerus, the tibia flattened at the extremity. Toes five in each foot, somewhat broad and short.

Chest covered with bony scales, which are thin, unequally ovate and about half as wide as long, and marked with obscure concentric lines. They have a thickened edge or margin interiorly. They are arranged in chevron and close together, forming a compact armour. There appears to have been a rhombic breast-plate in front, with obscure radiating lines, but this has only been found detached.

Skin of upper surface of body minutely granular or scaly, with a semicircular patch of horny tubercles in front, which I have referred to the snout, but it may have belonged to the back of the head. On the throat or sides were flat, pointed, and apparently flexible lappets marked with elongated areoles and pores. Nearly the whole skin of some specimens has been preserved in the erect trees apparently by a sort of tanning process, but it is so flattened and crumpled that its form is scarcely discernible.

The following are the dimensions of two specimens, one of them (No. 2), that of 1890, and the largest yet obtained:—

	No. 1.	No. 2.
Length of Skull *	7 centimetres.	9 centimetres.
Breadth of Skull *	5 ,, ...	6 ,,
Length of Mandible	6·6 ,, ...	8·6 ,,
,, Humerus	3·5 ,, ...	4·3 ,,
,, Ulna	2·5 ,, ...	— ,,
,, Femur	2·6 ,, ...	— ,,
,, Rib	2· ,, ...	2·8 ,,
,, Eleven vertebræ ...	5·6 ,, ...	— ,,

* The skulls being flattened and crushed, these measurements are not certain.

In form, *Dendrerpeton Acadianum* was probably elongated and lizard-like; with a broad flat head, short stout limbs, and an elongated tail; and having the skin of the belly protected by small bony plates closely overlapping one another, while the upper part of the body was covered with a tough skin more or less scaly and ornamented in parts with lappets or pendants. As in the case of other small Reptilians of the Coal, its enemies were found rather below than above. Its armour therefore was beneath.

The bone-cells are broad and with much-branched canaliculi, those of the bony scales being similar to those of the other bones. The hollow bones are occupied with calcite stained brown and probably representing cartilage.

Not having visited the Joggins for some years, and the gentleman on whom I had relied to give me intimation of new exposures of reptiliferous trees having left the locality, I made a short excursion to the place last summer, and found two trees partially exposed in the reef. These were extracted with the kindly aid of Mr. McNaughton, Superintendent of the Joggins Mine, but unfortunately proved unproductive. A large tree had fallen from the cliff in the previous winter and had possessed a layer of very productive material in its lower part, much of which had however been removed by the waves. I succeeded in obtaining a portion of this material, which on examination proved to contain parts of the skeletons of two specimens of *Dendrerpeton Acadianum* and one of *D. Oweni*. No other reptilian bones nor remains of millipedes or of land shells were observed.

The specimens of *D. Acadianum* were the largest yet found, and some of the bones were in a more perfect state. As examples of these I figure (Fig. 1) the two mandibles of the largest specimen. These seem to have separated on the decay of the body and to have fallen across one another, so that they lie side by side and reversed. They are 8·6 centimetres in length, and one of them shows very well the corrugated sculpture of the bone and a number of the teeth. On the same slab, represented in Fig. 1, is a well-preserved humerus. It has been exposed by cleaning away some of the stone, which probably contains other bones of the fore-leg; but they cannot be worked out without destroying those in sight.

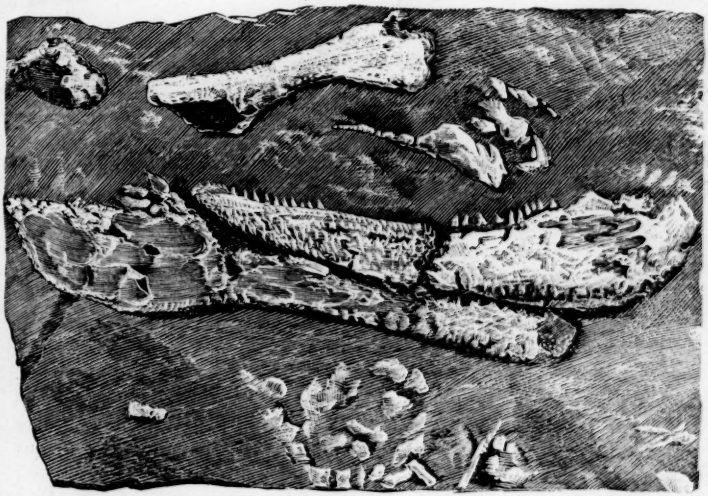

Fig. 1.—Humerus and Mandibles of *Dendrerpeton Acadianum*. Natural size.

I would call attention to the humerus as indicating the development of the fore-limb in this species. The bone in this probably mature specimen is better ossified than in smaller and probably younger specimens. In length it is 4·3 centimetres, or half that of

the mandible, thus exceeding in relative size the humerus of the American Alligator, while its form indicates a limb of much muscular power. Other specimens show that the hind-limb was not larger than the fore-limb; on the whole it was perhaps feebler, so that in this animal there was no approach to that exaggerated size of the hind-limb seen in some of the larger Labyrinthodonts.

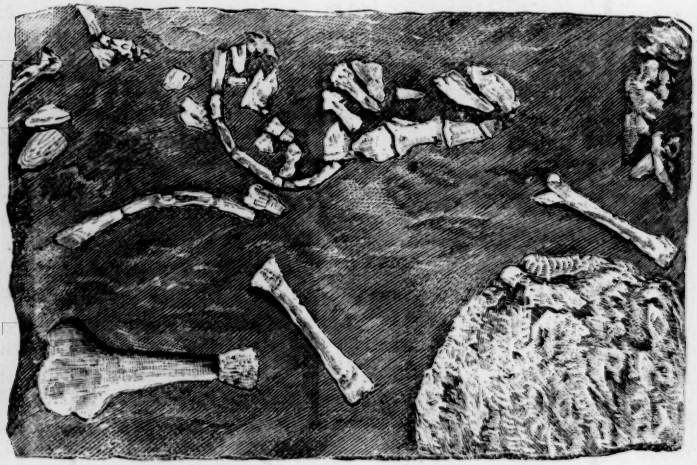

Fig. 2.—Ribs, Phalanx, Scales, Scapular bones, and part of Skull of *Dendrerpeton Acadianum*. Natural size.

The slab represented in Fig. 2 shows the anterior part of the crushed skull, giving its broadly rounded form in front, and the sculpturing of the bone. After the photograph from which the cut is copied was taken, a portion of the matrix was removed, so as to expose the outer teeth on one side and one of the large inner teeth. One of the former with the sculpturing of the edge of the maxillary bone is represented enlarged in Fig. 3.

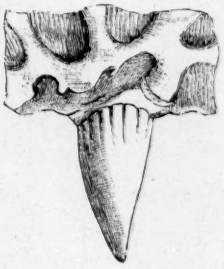

Fig. 3.—Outer tooth and portion of Maxillary bone of *Dendrerpeton Acadianum*.—Enlarged.

On the slab Fig. 2 are two slender bones and a larger bone which I suppose to be parts of the shoulder-girdle. There are also two of the anterior ribs and some bones of the foot (among them a phalanx

showing portions of four of the bones in position, and giving for one of the toes of the fore-foot a length of about 2·3 centimetres; also a few of the anterior abdominal scutes. All the bones represented belong to the anterior parts of the animal; the portion of the tree containing its posterior parts had unfortunately been destroyed or removed by the sea.

I have remarked in previous memoirs that possibly the animals found in the erect trees, while they must all have been of terrestrial rather than aquatic habits, may in some cases have been young individuals of the species to which they belonged. This supposition is to a certain extent borne out by the present specimens, which are considerably larger than the corresponding parts of individuals previously found, and have the bones more ossified and more strongly sculptured. Possibly, however, we may not yet know the species in its full magnitude.

This suggests the question whether *D. Oweni* may be founded on still younger individuals of the same species. The likelihood of this is not, however, increased by the new discoveries. The specimen of *D. Oweni* found in the tree of 1890 is quite as distinct as those previously found. It has longer, more curved and pointed teeth, thinner and less sculptured cranial bones. The mandibles are only very feebly sculptured. The limbs and feet seem to have been similar to those of *D. Acadianum*, but the abdominal bony scales were narrower and more pointed or "oat-shaped," and the skin of the upper surface more distinctly scaly. On the whole, therefore, the evidence is in favour of *D. Oweni* having been a smaller species allied to, but presenting so far as known no connecting links with, its larger congener.

Hylonomus Lyelli, Dawson, Journ. Geol. Soc. Lond. vol. xv. 1859, p. 274.

Though the newly-found specimens throw no farther light on the amphibians of the group *Microsauria* found in the same repositories with *Dendrerpeton*, they have invited comparison and fresh study of the material previously obtained, and I desire in this connexion to state the reasons which have induced me from the first to maintain that *Hylonomus*, *Hylerpeton*,[1] *Smilerpeton*, and *Fritschia*[2] are not Labyrinthodonts properly so called, and belong to a quite distinct group, making in some respects nearer approach to the reptilian order to which the *Proterosaurus* of the Permian belongs.

We may take *Hylonomus Lyelli*, the best known of these animals, as a type, and I would state the following points of comparison with *Dendrerpeton*, and most if not all other typical Labyrinthodonts.

1. As to the skull, this is large behind and pointed in front, and its bones are smooth, while the teeth are perfectly simple, without any trace of fluting or plication of the enamel, and there are no interior large teeth. The nasal and maxillary bones are smooth, thin, and elongated. The parietal bones larger and more convex

[1] Owen, J.G.S. vol. xviii. 1862, p. 241.

[2] Dawson, Phil. Trans. Royal Society, 1882, pt. ii. pp. 638, 641.

than in most other amphibians. The bone which I suppose to be the parasphenoid has a long axial process, and the posterior end moderately broad. On the other hand, it is certain that the skull has an open parietal foramen, has a group of small palatal teeth, and has two occipital condyles.

2. As to the trunk. The vertebræ are long, hour-glass-shaped, biconcave, and ossified exteriorly, with large and broad neural and lateral processes. The ribs are well developed, curved, and with a double head. The scapular and pelvic bones are large, especially the latter, which has a very broad well-ossified principal bone, perhaps the ilium. The pelvic bones thus resemble those of *Diplovertebron*[1] of Fritsch, which is, however, an animal very different in other respects. I regret that I have had no means of ascertaining whether the pelvis of *H. Lyelli* was attached to one sacral vertebra or more. The large size of the pelvis would, however, render its attachment to a single vertebra improbable, and in the skeletons on the slabs (*a*) and (*b*), Fig. 4, there are in the vicinity of the pelvis pairs of vertebræ attached to each other in such a manner as to suggest that they were permanently united.

3. The limb-bones and ribs have a thin and hard outer bony coat, the interior being usually filled with calcite darkened by organic matter, probably remains of cartilage. The bones of the limbs and feet are long and slender, with well-ossified extremities, and their forms indicate slender limbs and active habits. The hind-limb in particular is somewhat larger than the anterior; and this with the size of the pelvis indicates a form of body broader behind, narrower in front. In farther connexion with this I have remarked in former papers that the skeletons of this animal always lie *on the side*, indicating that the body was flattened, not vertically, but laterally, as in some Lizards. This I regard as an important diagnostic character for *Hylonomus*, and it does not seem to apply to the genus *Hyloplesion* of Fritsch, which is flattened vertically, as well as much inferior in development of pelvis and limbs.

4. As to dermal covering, *Hylonomus* has the abdomen protected by bony scales, but differing in form and probably in arrangement from those of *Dendrerpeton*. The covering of its upper part was however peculiar to itself, presenting a perfectly scaly surface of true corneous scales and with ornamental tubercles and spiny epaulettes on the shoulders, of which there is no trace in any other known amphibian, recent or fossil. It also possessed pendant fringes of cuticle like those of *Dendrerpeton*.

In connexion with this statement, I copy here (Fig. 4) from my "Airbreathers of the Coal Period" an illustration of the scattered bones of a skeleton of *Hylonomus Lyelli*, and some of the parts enlarged, which will serve with the accompanying description to illustrate some of the structures. I have given in the paper above referred to, in the "Transactions of the Royal Society," a copy of a portion of the scaly armour from a micro-photograph.

[1] Plate 52, Fauna der Gaskohle. As interpreted by Fritsch, the flat bone is called the pubis.

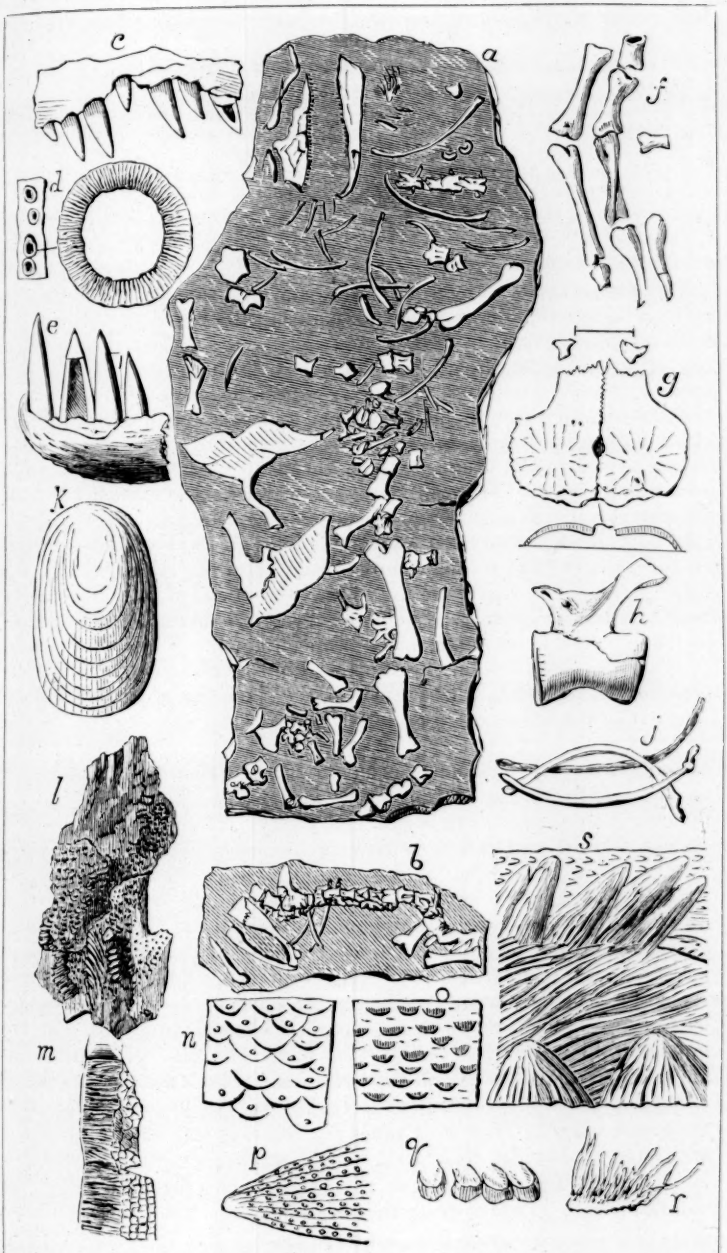

FIG. 4.—*Hylonomus Lyelli.*[1]

[1] Reprinted from "Airbreathers of the Coal Period," 1868.

FIG. 4.—*Hylonomus Lyelli*. EXPLANATION TO PAGE 151.

a. Skeleton in matrix, showing jaws, ribs, vertebræ, pelvis, and bones of limbs.
b. Portion of skeleton in matrix, showing vertebræ and limb-bones.
c. Portion of maxilla with teeth; enl.
d. Cross-sections of teeth; enlarged.
e. Anterior end of mandible with teeth; enlarged.
f. Bones of foot; enlarged.
g. Parietal bones, showing foramen; enl.
h. Vertebra; enlarged.
j. Ribs; enlarged.
k. Bony scale; enlarged.
l. Portion of scaly cuticle.
m. to *s*. Horny scales, bristles, tubercles, and other appendages of the same; magnified.

Hylonomus Lyelli was an animal of small size. Its skull is about an inch in length, and its whole body, even if, as was likely, furnished with a tail, could not have been more than six or seven inches long. No complete example of its skull has been found. The bones appear to have been thin and easily separable; and even when they remain together, are so much crushed as to render the shape of the skull not easily discernible. They are smooth on the outer surface to the naked eye, and under a lens show only delicate uneven striæ and minute dots. They are more dense and hard than those of *Dendrerpeton*, and the bone-cells are more elongated in form. A specimen in my possession shows the parietal and occipital bones, or the greater part of them, united and retaining their form. We learn from them that the brain-case was rounded, and that there was a parietal foramen. Well-preserved specimens of the maxillary and mandibular bones have been obtained. They are smooth, or nearly so, like those of the skull, and are furnished with numerous sharp, conical teeth, anchylosed to the jaw, in a partial groove formed by the outer ridge of the bone. In the anterior part of the lower jaw there is a group of teeth larger than the others. The intermaxillary bone has not been observed. The total number of teeth in each ramus of the lower jaw was about forty, and the number in each maxillary bone about thirty. The teeth are perfectly simple, hollow within, and with very fine radiating tubes of ivory. The vertebræ have the bodies cylindrical or hour-glass-shaped, covered with a thin, hard, bony plate, and having within a cavity of the form of two cones attached by the apices. This cavity was completely surrounded by bone, as it is filled with stained calc-spar in the same manner as the cavities of the limb-bones. It was probably occupied with cartilage. The vertebræ were biconcave. The neural spines are short and broad, with zygapophyses, and are not separable from the bodies, the neural arches being perfectly anchylosed to the bodies of the vertebræ. There are, on the dorsal vertebræ, strong diapophyses or lateral spines, to which the ribs were articulated. The ribs are long, curved, and at the proximal end have a shoulder and neck. They are hollow, with thin, hard, bony walls. There are short ribs which may be cervical. The anterior limb, judging from the fragments procured, seems to have been slender, with long toes, four or possibly five in number. The posterior limb was longer and stronger, and attached to a pelvis so large and broad as to give the impression that the creature enlarged considerably in size towards the posterior extremity of the body, and

that it may have been in the habit of sitting erect. The thigh-bone is well formed, with a distinct head, and the lower extremity flattened and moulded into two articulating surfaces for the tibia and fibula, the fragments of which show that they were much shorter. The toes of the hind-feet have been seen only in detached joints. They seem to have been thicker than those of the fore-foot. Detached vertebræ, apparently caudal, have been found, but the length of the tail is unknown. The limb-bones are usually somewhat crushed and flattened, especially at their articular extremities, and this seems to have led to the error of supposing that this flattened form was their normal condition; there can be no doubt, however, that it is merely an effect of pressure. The limb-bones present in cross-section a wall of dense bone with elongated bone-cells, surrounding a cavity now filled with brown calc-spar, representing cartilage. Nothing is more remarkable in the skeleton of this creature than the contrast between the perfect and beautiful forms of its bones, and their imperfectly ossified condition, a circumstance which raises the question whether these specimens may not represent the young of some reptile of larger size.

The dermal covering of this animal is represented in part by oval bony scales, which are so constantly associated with its bones that I can have no doubt that they belonged to it, being the clothing of its lower or abdominal parts; while above it was clad in the beautiful scaly covering above described. The scales are thicker than those of *Dendrerpeton*. On the inner side they are concave, with a curved ledge or thickened border at one edge. On the outer side they present concentric lines of growth. The companion genera above named are not known so completely as *Hylonomus*, but all their characters so far as known would place them with it as members of the same group rather than with *Dendrerpeton* and its allies. Of other American forms it appears to me probable that *Sauropleura digitata* of Cope[1] may be very near to my genus *Fritschia*, and agrees with it in having rod-like abdominal scales, but its head is not yet known. *Brachydectes* of the same author is very near to *Hylerpeton*, especially as specimens of the latter recently obtained show some characters, as the ascending ramus of the lower jaw, on which Cope distinguishes this genus.

Of Fritsch's species several may come within the group of Microsauria. The genus *Hyloplesion* of this author has indeed been united by Credner with *Hylonomus*, a position to which it scarcely seems entitled, and *Petrobates* of Credner is nearly allied, while *Seelya* and *Dawsonia* of Fritsch also approach to the characters of this order. Still the whole of these animals seem very inferior in development of limb and form of body to *Hylonomus*.

I regret very much that, owing, as I believe, to imperfection of material, so many palæontologists have failed to appreciate fully the characters of *Hylonomus* as a type of the higher Carboniferous Amphibia approaching to Reptilia.

Fritsch, in the conclusion of his important work on the Stego-

[1] Ohio Reports, vol. ii. p. 388.

cephala of the Gas-coal of Bohemia, has some valuable remarks on the affinities of these animals; and, though I can by no means agree with the manner in which he arranges them in families, or with the way in which he mixes up Labyrinthodontia and Microsauria with other creatures so different as the Branchiosauridæ and the Ophiderpeton group, I think his conclusions deserve mention, and may state them nearly in his own words as follows:—

After remarking on the fact that we know no clear links of derivation from any previous animals, he states that on any theory of derivation different origins must be supposed. He illustrates this by the characters of the vertebræ in different genera, as, for instance, the biconcave, the partly cartilaginous, and the diplovertebrate types.

Whatever view may be taken of their origin, the increased knowledge of their structures has not made clear as yet their precise relation to modern Amphibia and Reptilia; and only serves to make us doubt whether the distinctions recognized in the modern forms apply to these ancient creatures in the same degree. We seem indeed to have, both in the Labyrinthodonts and the Microsaurians, composite or generalized types having properties akin to those of both classes, and these in very different degrees. If we regard them all as agreeing in the general structure of the skull, with its free parasphenoid, and a similar set of bones in the shoulder-girdle, then we shall find that in other respects we have a heterogeneous assemblage, some agreeing in the formation of the vertebræ, ribs, and pelvis, with Amphibians, others with Reptiles; and there are corresponding differences in the dermal covering. If we attempt to group these creatures in orders and families, we are met with very great difficulties, owing to the variety and kinds of their differences, which, in connection with the imperfection of the material, almost defy the classifier.

So far Fritsch, and I may add that I consider that little is gained by grouping animals so diverse in organization under one head of Stegocephala in consequence of resemblances in certain cranial bones, and that a more general and large view should be taken of the *tout ensemble* of their structures.

With reference to that selection of these animals which has been preserved in the erect trees of Nova Scotia, the only ones which it has been necessary for me to study, I have no hesitation in placing in two orders or families, that of the Labyrinthodontia, to which *Dendrerpeton* belongs, and that of the Microsauria, including *Hylonomus*, *Hylerpeton*, *Fritschia*, and *Smilerpeton*, all of which have many important points in common. The other forms I leave to those who have to deal with them, but I feel convinced that some of them should be separated, probably ordinally, from the above.

The following extract from Credner on the systematic position of *Hylonomus* and *Petrobates*, shows that he to some extent shares in these views.[1] It should be understood, however, that his *Hylonomus*

[1] Zeitsch. Deutsch. geol. Gesellsch., Berlin, 1890, p. 257.

is *Hyloplesion* of Fritsch, and possibly not congeneric with *Hylonomus* proper, and certainly less reptilian in its characters.

"The question whether *Hylonomus*, and especially whether *Petrobates*, is to be classed with the Stegocephala or with the Rhynchocephala, is not one which can be at once decided. The long, bent, trunk ribs, the marking off of the cervical section by short differently-shaped ribs, the rhombic horned episternum, the bony pubica, the ossification of the carpus and tarsus taken together give both quadrupeds a reptilian habitus. In the case of *Petrobates* this becomes more pronounced by the occurrence of ventral ribs and of intercentral lower arches dovetailed in between the vertebral centres of the neck. On the other hand, *Hylonomus* and *Petrobates* have, like the Amphibians, only one sacral vertebra. A more primitive habitus is also presented in the persistence of the continuous chorda, in the insignificant superficial ossification of the elements of the skeleton, the absence of ossification in the heads of the hollow bones of the extremities,[1] and in the uniform shape of the small teeth.

"In *Hylonomus* this becomes strengthened by an apparently true stegocephalic skull-cover, as well as by the thick comb-like development of teeth in the roof of the mouth, and the presence of a ventral shield of bony scales.

"These several points of resemblance connect *Hylonomus* (*Hyloplesion*) rather with the Stegocephala, while *Petrobates*, on account of its ventral ribs and intercentral arches, comes nearer the *Rhynchocephala*. In other words, they both possess a general, as yet but slightly differentiated, common habitus, but in *Hylonomus* (*Hyloplesion*) the primitive type is more pronounced than in *Petrobates*, in which already a great specialization in the direction of the Rhynchocephala finds expression. If one, in considering *Petrobates*, disregards the skull, which is not accurately enough known, one might hold this quadruped to be a small Rhynchocephalian, of the family of the Proterosauridæ, if it were not that the presence of only a single sacral vertebra was opposed to this view. It appears as if *Hylonomus*, *Petrobates*, *Palæohatteria*, and *Kadaliosaurus* belong to a natural group of contemporaneous quadrupeds, representing however as many stages of specialization in the direction of Reptiles."

Bearing in mind that the typical species of *Hylonomus*, represented by *H. Lyelli*, are in some important respects nearer to *Palæohatteria* and *Kadaliosaurus* (which are regarded by all palæontologists as generalized reptilian genera tending to Amphibians) than either *Hyloplesion* or *Petrobates*, this conclusion of Credner becomes very significant as to the position of the Microsauria, and may be regarded as confirmatory of the conclusions which, though not a specialist in fossil reptilia, I have ventured to suggest in connexion with the species which I have been induced to study, in consequence of their connexion with my other work in Carboniferous geology.

It must be remembered that the repositories in which *Hylonomus* and its companions are contained are of an exceptional nature, and likely to have entrapped animals specially terrestrial in their habits.

[1] These characters do not apply in so great degree in *Hylonomus* proper.

I have elsewhere[1] referred to the fact that even in the basal beds of the Carboniferous (Horton series) there are footprints of quadrupeds of larger size than *Hylonomus*, which were digitigrade, and had a length of stride comparable with that of modern carnivorous mammals. I therefore anticipate the discovery, in these Lower Carboniferous beds, of reptiles of as high or higher grade than those hitherto found in the Coal-formation or Lower Permian, throughout which periods the same or similar forms seem to have prevailed.

II.—On the very Recent and Rapid Elevation of the Highlands of Eastern Asia.

By Henry H. Howorth, Esq., M.P., etc., etc.

(*Concluded from our last Number, p.* 104.)

THESE opinions of Mr. Campbell, however clearly and precisely stated, are so strong and emphatic, that I wish to confirm them by those of another experienced geologist, who worked much among the Himalayas, namely, General McMahon. In "Notes of a Tour through Hangrang and Spiti," published in the twelfth volume of the Records of the Geological Survey of India, he describes the existing glaciers and their remains in the district, and then says: "I do not know whether any one has ever supposed that the Himalayas were covered during the last Glacial period with an ice-cap, but I may note that whilst I saw nothing to favour such an idea, I saw much to negative it. The contour of the hills and valleys in those parts of the interior of the Himalayas that I have visited is sharp and angular, and where rounded outlines are seen, they are sufficiently explained by the action of subaerial forces on comparatively soft and friable rocks.

"But setting aside the idea of an ice-cap, the question remains—Was there formerly any great extension of local glaciers, and if so within what limits? To this question I answer that, whilst I saw evidence of the former extension of existing glaciers, I saw nothing during my tour to lead me to believe that these glaciers had ever, within a reasonable geological period, extended lower than 11,000 or 12,000 feet above the sea.

"On looking down from a high vantage ground, deep narrow side valleys may be seen on the Upper Sutlej, below that level, in which the course of the streams flowing through them is so sinuous that the sharp headlands formed by their sudden bends interlace like the nuts of cogwheels working into each other. The flow of ice in a glacier being analogous to the flow of water in a river and its tributaries, a grand glacier filling the valley of the Sutlej would not have prevented the flow of ice from the side glaciers into the main glacial stream. But had these side valleys ever been filled with glaciers, the sharp interlacing headlands would have been gradually worn down to smooth surfaces, and the valleys straightened and

[1] Trans. Roy. Soc. part ii. 1882, p. 653.

widened. The only valley in the Himalayas I have yet seen that is shaped like a glacier valley is the Spiti valley. The greater part of it is 11,000 feet above the sea, and its bottom, especially in the upper part of the valley, is broad and flat, while the bounding mountain sides rise abruptly in a wall-like manner at a high angle, and send no sharp projecting spurs into the valley" (*id.* p. 68).

Lastly Strachey, a very judicial observer, says, writing in 1880, "Till now no geological evidence has been adduced to indicate in this region anything corresponding to the Glacial epochs of Northern Europe, to which these former extensions of the glaciers could be attributed" (Ency. Brit. vol. xi. p. 831).

The evidence from the Himalayas must therefore be taken as proving emphatically the absence of anything like the glacial phenomena of Europe there. Notwithstanding the enormous height of that range, and its consequent efficiency as a condenser, and notwithstanding its close presence to a great sheet of water in Central Asia now dried up, it shows no traces of that great growth of glaciers which marked the same period in Europe and North America. I have no other explanation to give save and except the one I offered in regard to the similar phenomena in the Ural chain, namely, that this great mass and congeries of mountains was then non-existent.

If we turn to another kind of evidence, namely, that of the salt lakes, which are found scattered over the vast area occupied by the Highlands of Eastern Asia, we can scarcely escape the conclusion that they have formed within a not distant period a more or less continuous sheet of water, perhaps connected with the sea which once occupied the Uralo-Caspian depression. Humboldt reports a Mongol tradition that the part of the Desert of Gobi towards Erghi once formed the bottom of a sea more than a hundred leagues in diameter. The district is strewn with salt lakes, and the saline plants growing there are of the same species as the plants growing on the borders of the Caspian (Humboldt, Tableaux de la Nature, vol. i. pp. 95–97).

The Chinese reports about the country of Lob Nor are to the same effect, and are probably based on an induction from its physical appearance. Valikhanof says of Kashgaria: "The interior of the country is a sandy desert, the peculiar features of which first become visible in the eastern slopes of an undulating range of hills, of no great width, between Yanyshahr and Yarkand. From this region it gradually widens as it runs to the eastward, where it forms the vast Gobi devoid of all vegetation, though interspersed with reservoirs of brackish water, and where the sand is heaped in such lofty ridges that the inhabitants give them the name of Gag (mountain). The parts that lie at the foot of the mountains have a clayey soil, strewed with small stones, and in some places impregnated with salt" (Michell's Essays on Central Asia, pp. 110–111).

"There are many lakes in Little Bokhara," says the same writer, "all lying along the borders of the inner desert, and containing brackish water" (*id.* p. 118). Dr. Stolizcka, who accompanied Sir Douglas Forsyth's mission, speaks of the entire soil in the valley of

Kashgar as being very saline. South-east of Taitma a large quantity of pure salt in cubical crystals is collected, and he adds, "The fact that there is such a large quantity of saline matter together with salt swamps in the southern part seems to prove that the Jilga at least, and probably most of the others, had been washed out by the sea, and that while others had gradually, though only partially, drained off the saline matter, this one retained it, because it has at present no outlet. It is in fact a dried-up saline lake, which at some remote time was cut off from the sea of which it was a fiord" (Report of a Mission to Yarkand, pp. 472–473).

Richthofen, speaking of this wide plain, says, "It is girt round by a wide semicircular collar of mountains of the loftiest and grandest character, often rising in ridges of 18,000 to 20,000 feet in height, while the peaks shoot up to 25,000 and even 28,000 feet. The basin which fills in the horse-shoe-shaped space inclosed by these gigantic elevations, though deeply depressed below them, stands at a height above the sea varying from 6000 feet at the margin to about 2000 in the middle, *and formed the bed of an ancient sea*" (see "from Kulja to Lob Nor," by Prejevalsky, translated by Morgan, p. 138). Speaking of the Tarim River, the same geologist says: "The region through which it flows is highly charged with salt, springs of sweet water are rare, and only appear on the border of the mountains. Even in the high mountains the basins mostly contain salt, and in many valleys of the Altyn tagh, at a height of 11,000 feet, Prejevalsky found the water brackish. The water of the Tarim must therefore contain a larger proportion of salt than any other of the larger rivers of the world; and the unusual amount of evaporation must have produced a very large deposit of steppe salts of all kinds. The Chinese from ancient times have called the Lob Nor *the* salt lake in contradistinction to many other salt lakes" (*id.* p. 145). While Prejevalsky contests somewhat this evidence about Lake Lob, or rather explains it, he speaks continually of the saline character of the soil in the district he traversed.

Turning to the extreme west of the great plateau, Henderson's narrative of the journey from Lahore to Ladakh, p. 88, gives an account of the Karakash river valley. He speaks of depressions in the soil half full of brine, and some covered with a thick crust of common salt. He adds that the water of the Karakash contains salt, and Mr. Shaw told him that in winter it is like brine and quite undrinkable, and that the whole valley abounds in saline efflorescence (*op. cit.* pp. 88–89). Again, he speaks of the valley of the Chang Chenmo River as being, in certain places, all covered with saline efflorescence, and near the springs as smelling like decayed seaweed (*id.* p. 73). In the neighbourhood of Lungdung, again, he refers to efflorescence consisting of Epsom salts covering the plain, and in some places to a depth of many feet. Where springs exist they formed briny lakes, and clouds of salt are raised by the wind. The Pangong lake is about a hundred miles long from East to West. Each gallon of water contains 1000 grains of salt. And so I might continue.

If we go to the other extremity of the great plateau, namely, where it spreads out into the Desert of Gobi, we cannot read any traveller's report of its barren wastes scattered with salt lakes without coming to the same conclusions about it. Reclus describes it in his picturesque language: "The Gobi," he says, "like the Sahara, was formerly covered by the waters of the ocean, even on the elevated plateaux, old cliffs may be noticed, the bases of which are worn away by the waves, and long strands of round shingle stretch around the area which was formerly occupied by a now vanished gulf" (The Earth, p. 100).

It thus appears that the surface of the plateau inclosed by the great mountain ramparts of Asia bears continuous evidence of being the very recently (geologically speaking), desiccated bed of a sea, that is, bears witness to a very recent and wide upheaval.

Evidence that great masses of water have passed over the ground quite recently is forthcoming in the sheets of auriferous gravel containing the bones of the big mammals which are strewn over the flanks of the Altai in precisely the same way that they are over the Ural mountains, and necessitating the same conclusion; and the very wide-stretching mantle of shingle which Drew and others describe as covering large parts of the plateau of Ladakh, etc., seems to point the same moral.

Speaking of the beds in the elevated valleys of the Himalayas, Strachey says: "As in the case of the plain of India, we here, too, have no complete proof of the origin of these great nearly horizontal deposits; but it seems clear, from the materials of which they are formed, that they must have been laid out by water, either by the sea or by some great inland lake. They are largely composed of boulder deposits, and large boulders are strewn over the surface imbedded on the ground in a manner that seems only explicable as the result of the action of a considerable body of water (Ency. Brit. vol. xi. p. 828).

Again, the researches of Père David on the mountains separating China and Mongolia agree with the remarks of Stolizcka about the Kashgar country and of the authors of the Manual of Indian Geology, that the rocks themselves bear testimony to very recent disturbance on a large scale in this area; and following in the wake of Medlicott and others, Strachey says, "The general conclusion that may be drawn from the facts of structure thus briefly indicated is that the elevation of the Himalaya to its present great height is of comparatively recent occurrence" (Ency. Brit. vol. xi. p. 828).

The same view is maintained by Mr. Lydekker in regard to the outliers of the Himalayas, known as the Siwaliks, the upper beds of which belong to Pliocene, if not later times. He says, "In all the Jamu district, at all events, the Siwalik strata are carried up and contorted by the conformable underlying rocks; it is evident that these older rocks have only been raised at a comparatively recent period to the elevation at which we now find them, and that consequently in Siwalik times the whole of the outer belt of the Himalaya must have been much lower than at present." In another paragraph,

speaking of the Siwaliks, he says, "Even their topmost beds are contorted and crushed in every conceivable manner, indicating the lateness of the period down to which the upheaval of the Himalaya has extended" (Records Geol. Survey of India, vol. ix. p. 100).

But we have evidence which is still more striking, and which seems to me to point conclusively not only to the upheaval having been recent but rapid.

Buckland, in his Reliquiæ Diluvianæ, speaks of certain bones of Horses and Deer procured by Captain Webb from the Chinese Tartars of Daba, who assured him that they were found on the north face of the snowy ridge of Kylas, in lat. 32°, at a spot which Webb calculates to be not less than 16,000 feet above the sea-level. They are only obtained with the masses which fall with avalanches from the region of perpetual snow, and are said by the natives to have fallen from the clouds and to be the bones of genii. Their medullary cavities and cancelli were lined or entirely filled with white crystalline carbonate of lime, beautifully transparent, the bone being white and very absorbent to the tongue. With them were found the bones of Bears. The discovery of these bones in such a situation, amidst perpetual snow, and quite out of the habitat of Deer and Horses, naturally attracted Buckland's notice. He urged that they are carcases of animals drifted to their present position by diluvial waters (Rel. Dil. pp. 222–223). They seem to me to evidence very plainly the fact that the Himalayas have been very greatly elevated since the bones were deposited.

The instance quoted by Buckland does not stand alone. Strachey called attention in the seventh volume of the Journal of the Geological Society to the presence on the very high land forming the watershed between the upper streams of the Ganges and the Sutlej, at a height of from 4200 to 4800 metres above the sea, of beds of sand, gravel, etc., containing a multitude of bones of Horse, Ox, Deer, Rhinoceros, Elephant, etc. Writing quite recently he says of these remains, "The existence of the animals in the present condition of these regions would be wholly impossible; so that there is no room to doubt that these deposits have been raised from a comparatively low level to their existing great elevation of upwards of 15,000 feet, since they were laid out" (Ency. Brit. vol. xi. p. 828).

Again, Dr. Falconer, speaking of the Steppe of Hioondes between the Himalayas and the Kailasa range, which is 15,000 feet above the sea-level, says: "The tract in the emphatic language of Batten is shrubless and treeless, a vast waste supporting a few furze bushes and a sprinkling of the most Alpine vegetation; and the climate is one of polar severity." On this steppe remains of fossil animals have occurred, and notably of the Rhinoceros, and Dr. Falconer observes: "It is very certain that no Rhinoceros of the present time could exist for a day in such a habitat; and if we suppose the Tibetan species to have been clothed with a dense fur like the Siberian species, the carcase of which was brought to Pallas from latitude 64° on the banks of the Lena, still the tract could never

have subsisted it. . . . . " In the case of the Rhinoceros the incisor teeth are deficient in number, and the greater portion of them rudimentary in form, and even deciduous. It may, therefore, be very safely predicated of all the species, fossil or existing, that they could never subsist by browsing on a herbaceous vegetation; they want *the nippers* which enable the Horse and Ruminants to subsist on low grass; and their food must either be derived from large reeds, shrubs or trees, none of which are now found in Tibet" (Memoirs vol. i. p. 180).

Again, speaking of Lyell's theory about the possible transportation of the Siberian Rhinoceros, Dr. Falconer says, "But these conditions will not apply to the Hioondes; the Rhinoceros could neither have migrated to its mountain-locked plain, from the side of Hindostan by the passes where men and goats can hardly find their way save by the artificial aid of scaffoldings, nor is it apparent how they could have been transported to their present resting-place from a higher tract" (Mems. p. 180). He then goes on to postulate an upheaval on a huge scale of the whole Himalayan range since the Rhinoceros was living there.

In support of Dr. Falconer's view about the impossibility of a large herbivorous fauna having lived in these high valleys under present conditions, I should like to quote Mr. Drew, who was very familiar with the plateaux of Ladakh. He says, "Vegetation exists but here and there; generally every ten or fifteen miles is to be found some *burtse* or Eurotia, the plant that serves for fuel, although at one halting-place moss is obtained in its stead, and at another neither *burtse* nor moss can be got. Pasture is still rarer; on leaving the last halting-place in the Chonglung branch of the Chăngchenmo valley, we had to pass over 60 or 70 miles before reaching any grass; the first find was at Lokzhung, a halting-place in the middle of the mountains of the same name. On the Kuenlun plains grass is equally scarce. . . Of wild animals one would think from the footprints that great numbers must live in the plains and the surrounding mountains; but one sees few, and on reflection it appears that the many footprints are the work of a comparatively small number of individuals, for in this country a mark may stay unobliterated for years" (Jummoo and Kashmir Territories, p. 352).

Recently (Records Geol. Survey of India, vol. xiv. part 2), Mr. Lydekker has discussed these remains, and arrived at a different conclusion to Dr. Falconer; but I confess I cannot follow his reasoning. He once deemed them to be of Siwalik and not of Pleistocene age. He now admits they are of the latter period, Mr. Griesbach having found the beds from which they came, and found them lying horizontally upon highly-tilted Tertiaries, which are presumed, says Mr. Lydekker, to correspond with some members of the Siwalik series of the outer hills.

Their age being unquestioned, Mr. Lydekker objects to the beds having been raised since they were deposited to the extent of 15,000 feet, because they are horizontal. A few paragraphs further on he allows that he would not have been surprised if the elevation had

been only 1500 feet, and he further adds that "the possibility of such a minor elevation is countenanced by the fact that the Pleistocene lacustrine strata of the valley of Kashmir have undergone a considerable amount of disturbance." This means, I presume, that beds will maintain their horizontality if raised up 1500 feet, but not if they are raised 15,000. To me the very reverse of this seems to follow. An elevation of 1500 feet means that the force probably operated over a small area and would cause a great deal of local disturbance. An elevation of 15,000 feet operating over the immense area covered by the highlands of Eastern Asia would mean the possible and probable raising of large areas without disturbing their horizontality.

Nor can I understand another argument of Mr. Lydekker's, namely, that there were probably some considerable sheets of water in Tibet which would modify the climate considerably, and make it possible for these large herbivores to live there at the present altitude. That the presence of more water would modify the climate is certain, but assuredly not in the direction Mr. Lydekker urges. Water at 15,000 feet above the sea-level would feed glaciers and not trees. The reason why the present Himalayan glaciers are so shrunk is, it seems to be entirely due to the desiccation of the country, and if there were only watery vapour to condense, the Himalaya valleys, 15,000 feet above the sea-level would assuredly condense it fast enough. This is the very reason why the glaciers are so much higher on the northern flanks of the Himalayas at the present moment than they are on their southern slopes. As Thompson long ago said in his admirable book, "In comparing the glaciers of the Tibetan Himalaya with those on the Indian face of the same mountains, it will be found that *cæteris paribus* glaciers descend much lower on the Indian side, or in a moist climate, than in the dry and arid Tibetan climate" (*op. cit.* p. 580).

We may take it, therefore, as certain, that if present conditions are incompatible with the existence of a varied herbivorous fauna, those postulated by Mr. Lydekker must have been much more so, and it seems to me that Dr. Falconer's argument remains absolutely intact, or is rather strengthened by Mr. Lydekker's. It is strengthened also by a fact long ago noticed by Thompson and Cunningham.

Thompson, in his Travels in the Western Himalayas, more than once mentions finding fresh-water shells in lacustrine clays at great heights; *ex. gr.* at Kyuri he found a few small shells, among others a *Limnæa* and a *Planorbis*. The clay was covered by a coarse alluvial conglomerate (*op. cit.* p. 117). Again near Lake Thogji Chumo, he found shells in prodigious abundance. This was 15,500 feet about the sea-level. A day's journey further on he again met abundance of shells in the clay, nearly all *Limnæa*, but occasionally there was a small *Cyclas*. The lake, which is now salt, must, Thompson urges, have been fresh when these molluscs lived in it (*id.* pp. 170–2). Again, at the lower part of the Nubra, about 10,300 feet above the sea-level, he again found the shelly clay covered with some fifty feet of detritus. The shells, he says, which were all

small, were species of *Planorbis* and *Limnæa*, apparently identical with those afterwards found in the neighbourhood of Iskardo, but quite different from those of the salt lake of Thogji (*id.* pp. 198–9).

Cunningham not only refers to the same fact, but explains it. Speaking of the former presence of wide sheets of fresh water in Ladakh, he says, "Their existence is further proved by the abundance of *fresh-water* shells that are found in the sandy clay deposits around the present *salt-water* lakes and on the dry plain of Kyang. These shells are of two kinds. *Limnæa auricularia* of all sizes and *Cyclas rivicola*, which is only found of very small size preserved in the interior of the larger shells. As these mollusca, says Cunningham, do not now exist in Ladakh at a greater elevation than between eleven and twelve thousand feet, it seems a probable conclusion that the country must at some former period have enjoyed a very much milder climate than that of the present day" (Cunningham, Ladakh, p. 193). That is to say, the level of the country must have been much lower.

The kind of evidence I have here adduced might be multiplied, but what I have quoted must suffice for the present, and to what does it testify with most converging emphasis? Assuredly to the conclusion that the great mountain masses of Eastern Asia, with the plateau they girdle and support, form a very recent feature in physical geography, and that the date of their upheaval was in all probability as late as the time when the Mammoth age came to an end, and when the remains of that great Elephant and his companions were scattered over the flanks of the Altai, and his contemporaries were entombed among the snows of the Hioondes valley in far-off Tibet. The evidence of this seems to me to be overwhelming, and it becomes still more so when it is not only found to be consistent with, but to alone explain how the former mild climate of Northern Siberia was converted into a very severe one, how the great Asiatic Mediterranean was drained of its waters and a large portion of its bed converted into the salt-incrusted plateaux of Tibet and Kashgaria, and how its drainage swept away the fauna of Northern Asia, and not only drowned the animals, but buried their carcases intact under continuous beds of gravel and clay over many degrees of longitude. Among the sympathetic readers of my Mammoth book there have been some whose judgment I highly prize, who have often asked me for a cause capable of such effects as I there postulate. In regard to those effects in Asia at all events, it will be admitted that, granting the validity of my induction, I have produced in this and recent papers, published in the Geological Magazine, a cause which is competent and which explains all the facts. The argument of my book extended of course beyond the limits of Asia, and perhaps I may be permitted in another paper to apply the reasoning I have here employed to the Great Cordillera of America.

III.—Further Notes on Fireclays, etc.

By W. Maynard Hutchings, Esq.

THESE notes are in continuation of my former paper "On the Probable Origin of some Slates" (Geological Magazine for June and July, 1890). Since its publication I have endeavoured to obtain a little further knowledge of the constitution of the fireclays of the Coal-measures, which I regard as so well calculated to throw light on the origin of many slates, and especially I desired to get, if possible, a little more evidence as to the supposed regeneration of mica in them, in connexion with the intimately associated question of the rutile-needles.

With this object I have tried to get as good a separation of the components of the clay as the very unfavourable nature of the material will allow, and this I have done by means of a rather prolonged and tedious course of what may be called "fractional levigation." This may be carried out in various ways, but the method I have found best suited is suspension of thoroughly disintegrated clay in water in large beakers, and syphoning off the suspended portion after appropriate periods of settlement.

The results of such levigation, though naturally very imperfect, still provide a material for microscopic examination from which some information may be had which could not so well be obtained from "sections" of clay, and which to some extent supplements and confirms what was formerly observed.

Taking again the fireclays of the Cliffs at Seaton, described in my former paper, about a cubic inch of the finest-grained bed was used. It was air-dried and crushed to powder, but not ground. It was then reduced to fine mud by crushing gently in a mortar with water, and finally left several days in water in a beaker, with frequent agitation, to insure as complete disintegration as possible. Preliminary trials showed that a sufficient degree of classification for my purpose was obtained as follows:—The whole was well stirred up in a beaker (11 inches deep by 6 inches wide) and two-thirds of the contents syphoned off after one and a half hours. This was repeated very many times till practically nothing more was taken over. The united material so obtained was again differentiated by suspension in water and drawing off after half an hour, and this second portion was again treated in a similar manner. Thus, three divisions of the first, finest, part were obtained, A, B, and C.

The residual original clay was next separated by repeated drawing off after 15 minutes' settling, and the portion drawn off was divided into two by a similar process, giving D and E.

The next stage was to draw off after two minutes' settling, and again divide the resultant part into two, giving F and G, leaving a final coarsest residue of the original clay, H.

Nothing is obtained from these fireclays at all approaching in fineness what is observed when fresh deposits, and some recent clays, are suspended in water; material which remains many days in suspension. Everything settles in a few hours, and such original fine slime is long since consolidated and altered into denser matter.

These various portions separated were collected by settling into smaller and smaller beakers, and finally, as thick mud, into stoppered bottles. They were mounted for examination by mixing some of the mud with a very little gum-water and painting very thin films on the slides with a camel-hair brush, drying, and covering with balsam and thin covers. With a little care even the finest portions could thus be got so that single flakes and grains could everywhere be examined.

The three finest portions A, B, C, under the microscope are seen to contain far away the largest portion of the rutile-needles of the clay. These are exceedingly abundant. The main portion of these finest slimes consists of very minute flakes, the smallest of which, especially in A, can only be seen when examined in water instead of balsam, many of the others being only seen in balsam by lowering the condenser very much. Without specifying anything further, it is safe to say that most, if not all, of this distinctly flaky material is micaceous; and as A, B, C make up a large part of the portion levigated, this very small micaceous substance is a leading component of the original clay. The larger bits are distinctly seen to have a greenish or yellowish tinge. Not a single bit can be seen which could for a moment be mistaken for biotite. In no case is any bit seen which *contains* rutile; the two minerals are here quite separate.

Micaceous ilmenite in small flakes, and little plates and grains of epidote, are rather abundant, also a good deal of matter too minute for any sort of identification. I cannot make out anything that could be safely referred to "Kaoline."

In the next grades, D and E, we of course get among larger-grained material, and here a considerable number of flakes are seen more or less full of rutile-needles. It was such flakes which I was specially anxious to isolate.

The first thing to remark about them is, that though they vary a good deal in size, the *upward* limit is pretty sharply marked off against the flakes which do *not* contain rutile; and when the next coarser grades of levigated material, F and G, are examined, this is again strongly emphasized. The number of rutiliferous flakes is much less than in D and E, and those present are largely due to the carrying over of one grade into another;—to the inevitable imperfection of the separation.

Considering then the whole of the rutiliferous flakes in D, E, F, G, those over $\frac{1}{1000}$th of an inch in largest diameter are rare, those reaching to that size are not a large proportion; the fairly average size of what might be called the larger flakes being about $\frac{1}{1500}$th of an inch across. From this downwards there are all sizes till a lower limit is reached, beyond which, as in A, B, and C, no *contained* rutile is seen.

If the flakes are studied in detail, it is soon seen that only some of the smaller ones are *single* flakes at all. Every larger one is seen, by its extinctions, to be an aggregate of more or less numerous smaller flakes overlapping one another, and with different optical

orientation. The majority of these complex flakes have all their component flakelets lying flat in one plane; but some are seen, especially among the coarser material of F and G, which are more or less globular aggregates, in which the mica lies at all azimuths, those bits seen edgewise depolarizing very brilliantly.

I may here remark that when the same levigation-process was carried out with a coarser band of the Seaton clay,—the grade of coarseness next following the fine fireclay,—just the same results were obtained. A much less relative proportion of the finer material was obtained, of course, but what was got was similarly composed, and the limits of size of the rutiliferous flakes were the same.

Most patient search was made for flakes which might allow of tests in convergent polarized light; but not one could be found of sufficient size which was not complex, and therefore useless for that purpose. One or two "figures" which I thought I had obtained, in "sections" of the clays, from rutiliferous flakes, are therefore very doubtful and of no value; probably due to original muscovite imperceptibly mixed in with the secondary minerals.

The same difficulty occurs in examining slates. Not in the thinnest parts of the thinnest sections it is possible to make have I ever succeeded in finding a single simple flake of the rutiliferous mica. It is all a felted complex of small flakes, exactly similar to the larger of the complex flakes in these clays.

The study of A, B, C, in conjunction with the coarser grades, leaves no doubt on one's mind that the bulk of the material of the former results from the disintegration of the complex flakes and globular aggregates described; the rutile lies mainly in between the minute component flakelets, and is set free when these are detached, except in relatively few cases of larger single flakelets.

There will also doubtless be present in the finest slimes more or less of minute flakes of original muscovite, though most of this mineral in this fine state of division has, I think, been absorbed into the new combinations.

In all the coarser grades there is present a good deal of original clastic muscovite, much more than would be supposed from examination of *sections* of clay, where much of it is hidden. All this muscovite is perfectly colourless and clear, and free from any trace of rutile. The supposed secondary mica is all very distinctly coloured, mostly yellow, sometimes greenish, and larger flakes are more or less turbid.

Flakes of altered biotite are also not scarce, now that levigation has set them free. They are relatively large, easily recognized, still considerably active in polarized light and dichroic when seen edgewise, but flat sections are all quite inactive in convergent light, being all more or less advanced in the process of waste and bleaching, with the same formation of epidote, etc., as described in the coarser material in my former paper.

No such flakes which can be identified as biotite in any stage of decay contain any rutile whatever.

There is nothing special to remark about the other minerals in these coarser parts of the levigated clay. Quartz and felspar grains

appear,—the latter scarce,—all completely rounded and many carrying more or less a skin of rutiliferous "paste," in spite of all the washing and agitation. I think it is really corroded on to the substance of the grains in many cases. A few beautiful little crystals of anatase, both pyramidal and tabular, are not missing.

Looking at the facts stated, the one which appears to have most bearing on the main point concerned is the pretty strict upward limit of size of the rutiliferous flakes.

If we suppose the rutile-needles to have been contained, as such, in the original clastic material as it was deposited in these beds, then we should find no such limit of size. If the rutile were contained in the micas, for instance, we could not well find any reasoning to explain why only flakes up to a certain small size should be rich in it, while those of larger size, from which the smaller ones *must* have been derived (on the supposition that what we now see is all primary deposit), should be absolutely free from it. These rutile-needles are, as I have before maintained, the key to the whole question. Some writers have simply ignored them, others make very light of them. Thus Roth (Chemische Geologie, vol. ii. 1887, p. 586) doubts that any proof has been given of the authigenic origin of the rutile-needles in slates; and again in his latest volume (Allgemeine Geologie, vol. iii. 1890, pp. 169–170) returns to the subject and contests the views of Rosenbusch and Lossen as to the secondary origin of the colourless mica of clay-slates, dealing with the rutile-needles by saying that "separation of the titanic acid of weathered micas as rutile is often enough observed."

As regards this supposition, that the rutiles in question in these fireclays may be due to any simple weathering of biotite, the same argument as to the size of flakes appears again to be difficult to answer. We might, perhaps, say that the larger the flakes the less they would be susceptible to such weathering. (This is not the case with the process of decay of biotite, pure and simple, as described in my former paper. The large flakes suffer as much as smaller ones. Nor does it seem true of biotite in any sort of weathering; chloritization, for instance. Big flakes are attacked as easily as little ones, the extreme fissility apparently counterbalancing the greater size.)

But even on this supposition no approach to a sharp line would be seen; the diminution of the amount of weathering and of the resultant rutile would be more or less gradual in proportion to size. Of course we know that biotite does sometimes give rise to rutile directly during weathering. What are the conditions, either in the original biotite or in the method of weathering, which cause this, we do not know; but we do know that it is relatively rare compared with the universal weathering of biotite *without* any formation of rutile.[1]

[1] In those cases where the separated rutile is arranged in approximately hexagonal star-forms, more or less conformable to the symmetry of the containing mica, I consider that it is due to other causes than weathering, viz. sometimes to original crystallization, but more often to powerful dynamic action, and that it is in the same category as the symmetrically arranged rutile in some micaceous ilmenite, and in sagenite.

But in these deposits, derived from granite-waste, the biotite is clearly seen not to give rise direct to any crystals of rutile, any more than it does in most granites, etc., where it is undergoing decay *in situ*.

The effect on my own mind of studying the slates, passing from these to the fireclays and associated shales (for reasons formerly stated), and back again to the slates, having approached the matter without any bias one way or other, is that I cannot come to any other conclusion than that the main mass of mica,—all the rutiliferous mica,—of the slates is a new formation, posterior to sedimentation; that in the fireclays and shales the same thing has commenced and progressed in the same manner up to a certain stage; and that most of our slates were produced from deposits of closely similar nature by a continuation and intensification of the conditions involved.

I must thank Dr. Irving for his very kindly and encouraging remarks (in the GEOLOGICAL MAGAZINE for December) concerning the value of my little study of the clays, etc., but I do not think I can quite follow him in the conclusions he draws.

For one thing, will it be quite safe to say that the fireclays of Northumberland (or any other Carboniferous clays and shales) have undergone no dynamic metamorphism whatever, even though what has taken place did not suffice to alter the deposits into hard cleaved slates?

It has suggested itself to me that possibly the more or less close association of these beds with the yielding coal-seams may have largely tended to preserve them from any of the severer effects of pressure, etc.;[1] but I am quite inclined to think that we are justified, on geological evidence, in assuming that they have taken part in conditions which could well be classed as "dynamic."

If I have, as Dr. Irving says I have, "simply ripped up" the idea of the "dynamometamorphic" origin of the secondary minerals in slates, I can only say that I had it not in my mind to do this savage and gory deed at all. If I have done it (which I do not see), then I am in the painful position of having unintentionally ripped up a friend, for I certainly believe that the completion of the regeneration of the materials of the deposits resembling the fireclays,

[1] It is stated in works on geology that the "underclays" of the Coal-fields are *unstratified*, and though I am not aware that this is so uniformly the case as to allow of its being given as a universal rule, still it is no doubt true enough when taken as referring to the clays occurring with workable seams of Coal. It is not by any means so as regards beds of exactly the same materials which occur in the same Coal-fields, either without any immediate connexion with Coal-seams, or only with very thin seams, far too thin to work. This unstratified condition of many fireclays is probably due simply to the crumpling and crushing they have undergone in connexion with the compression of the materials out of which the Coal was formed. It is also, no doubt, quite true as stated in the book (first suggested by Sterry Hunt), that Clays on which the Coal-vegetation actually grew were deprived of much alkali by the plants. It is therefore more desirable in studying these deposits, as bearing on the origin of slates, to select beds which have not had the stratification disturbed and which have no Coal in actual contact. This is the case with the beds at Seaton Cliffs, which I have used so much as my principal type and source of material.

and their formation into slates, was the result of very severe "dynamometamorphic" action and could not be brought about, as regards the coarser parts of the deposits, without its aid. Still, these are only "views," and nobody's views are of very much authority in the present state of our knowledge of these matters. We want, perhaps, more facts and less views. My excuse for stating mine above must be my desire to escape some remorse for the thing Dr. Irving says I have done!

I may mention that since my first paper I have examined clays and shales from the Derbyshire coal-field (Clay Cross), and with the same results. Materials from all the coal-fields seem to be of like nature, derived from the same or a similar source,—a granite (or gneiss?) with two micas, biotite being in excess.

As regards the composition of all these fireclays, I would once more emphasize the fact that they are *not* "hydrous silicates of alumina." The results of chemical analysis chance to lend themselves tolerably easily to this interpretation; but it is quite a wrong one. The analyses are quite as well suited to a material mainly composed of strongly hydrated altered micas. Writers dealing with fireclays seem to have thought that every chemical analysis must be worked up into a "formula," just as is done so much in the case of metallurgical slags, even though in both cases a glimpse through the microscope would show the complexity of the substance and the uselessness of the formula.

Woodwardian Museum Notes.

IV.—On Various Crystalline Rocks.

By Alfred Harker, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

(i.) *Pyroxenite (Websterite) from Fobello, Lombardy.*

CRYSTALLINE rocks containing neither felspar nor olivine have received but little or no attention, except from one or two American geologists. Dr. G. H. Williams[1] has recently drawn attention to these rocks, of which he proposes to constitute a family of Pyroxenites coördinate with Rosenbusch's family of Peridotites; and has described from Maryland and North Carolina a type consisting entirely of monoclinic and rhombic pyroxenes, to which he gives the name Websterite. The occurrence of a similar rock in Northern Italy seems worth recording. Our specimens were collected by Mr. E. J. Garwood.

To the eye the rock appears as a coarsely crystalline aggregate of lustrous black diallage, in which the rhombic pyroxene which forms the second constituent is scarcely to be distinguished. The specific gravity of the rock is 3·229.

A slice [1086] shows the rock to consist of large plates of diallage moulding smaller grains of hypersthene, neither mineral having any external crystal form.

The hypersthene is the first-formed mineral, and builds irregular

[1] American Geologist, July 1890.

crystal-grains up to one-tenth of an inch in diameter, showing marked pleochroism in pink and green tints. Cleavages parallel to the two pinacoids occur, in addition to the usual prismatic cleavage. There is often a minute "schiller" structure, apparently parallel to the brachypinacoid, besides larger inclusions, which have the same orientation, and appear to be of the nature of rhomboidal cavities filled with some dark brown ferruginous material. The absorption-colours, so far as can be made out in random sections, are, parallel to

α=a ... rose-pink;
β=b ... nearly colourless;
γ=c ... pale apple-green.

The diallage is in colourless, irregular plates, often slightly bent. It shows rather broad bands following the orthopinacoidal parting and corresponding to the "solution-planes." These bands are occupied sometimes by a colourless and highly birefringent crystalline mineral like calcite, sometimes by brown or greenish-brown matter. There is a strong cleavage always making a high angle with these bands and probably parallel to the basal plane; this, too, seems to be a direction of chemical weakness, though a less marked one. Less pronounced cleavages correspond, no doubt, to the prism-faces.

The only other mineral which can be considered original is a deep brown, pleochroic hornblende, which occurs rarely, in small scraps, intergrown with the diallage near its contact with the hypersthene. There is no trace of felspar or olivine, nor any original iron-ores or other accessory minerals.

Though often quite fresh, the hypersthene sometimes shows alteration into a minutely granular aggregate which gives high polarization-tints. The change begins in veins following cleavage cracks, but may destroy the whole of a crystal, so that nothing is left of the original structure of the hypersthene except the dark-brown schiller-inclusions mentioned above. Into the spaces thus occupied by the obscure alteration-product, project jagged fringes of colourless, brightly-polarizing hornblende, which, although formed at the expense of the rhombic pyroxene, grows as an extension of the diallage, towards which it is oriented in the usual crystallographic relation.

(ii.) *Eclogite from Port Tana in the North of Norway.*

This rock, collected by Mr. R. H. Solly, shows in a hand-specimen plenty of red garnets imbedded in a yellowish-green crystalline mass in which pyroxene (omphacite) is evidently the dominant constituent.

In a slice [962] the garnet shows an irregularly rounded outline and a faint pinkish tinge. Some of the crystals are distinctly double-refracting. This character is not associated with any polysynthetic structure, and may be due to internal strain; it is sometimes more marked in the vicinity of certain inclusions. A constant feature is the presence of countless minute rods accurately alligned in three directions parallel to the three crystallographic axes. They belong to a clearly double-refracting mineral, and give extinction-

angles up to about 31°. This agrees with disthene or cyanite, a mineral described by Riess[1] as a common constituent of eclogites. Among the other minerals included by the garnet may be mentioned quartz and apparently omphacite, mostly in round granules clustered in the centre of the crystal; zircon, commonly in little well-formed crystals, bounded by the pinacoids (100) and pyramid (111); and locally, near the margin of the garnet, crowds of little prisms with moderate double refraction and sensibly straight extinction, possibly zoisite. Some larger rounded grains of quartz containing little zircons are inclosed near the border of the garnets, and occasionally a small flake of brown mica. Larger flakes of mica, with strong pleochroism, occur in densely-packed bundles moulding the surface of the garnets.

The rest of the rock consists chiefly of a crystalline granular aggregate of colourless omphacite and clear quartz, the latter giving 'undulose' extinction, and often crowded with the straight hair-like rods usually referred to rutile. This aggregate, however, incloses numerous idiomorphic, though rather rounded crystals of enstatite with a longitudinal striation and strong cleavage. There are also a few scattered rod-like crystals of reddish-brown colour, and not more than a tenth of an inch in length. These belong to a uniaxal mineral with exceedingly high double-refraction and slight, though distinct, dichroism ($E > O$). It is evidently rutile, a mineral not admitted in Riess' monograph, but recorded by Möhl[2] in some of the Norwegian eclogites. The crystals are simple tetragonal prisms, either (110) or (100).

(iii.) *Garnet-Amphibolite from Sutherland.*

The locality is three miles south of Laxford Bay. The rock shows abundant red garnets imbedded in a mass of greenish-black hornblende. A curious feature is the well-marked series of parallel cracks by which the garnets are traversed. These maintain a constant direction throughout the specimen, but do not affect the hornblende. They are evidently due to stress in the rock, and, though better developed, are of the same kind as the cracks seen in the garnets of various crystalline rocks, such as the Eddystone gneiss and some of the Saxon granulites. These cracks are always at right angles to the direction of 'stretching' in the rock, and so perpendicular to any foliation or schistosity that may be present.

A slice [1254] shows the rock to be composed chiefly of garnet and green hornblende. The garnet retains its red colour, and shows well the series of parallel cracks preserving a common direction throughout the slide. There is a less pronounced system of cracks roughly perpendicular to the first. The crystals are of irregular shape, but tolerably free from inclusions. They show no double-refraction, nor does the rock as a whole present any trace of foliation or other parallel structure.

The hornblende is in rude columnar crystals without terminal

[1] Tsch. Min. u. petr. Mitth. 1878, vol. ii. pp. 165–172, 181–241.
[2] Nyt Mag. Naturvidensk. vol. xxiii. (1877), pp. 128–137.

planes, and often so massed together as to prevent their free development. It constitutes nearly half the bulk of the rock. The colour is an intense grass-green, the absorption being, parallel to a yellow-green, β and γ deep grass-green, almost opaque. The extinction-angle $c\ \gamma$ is high, perhaps as much as 20°, but cannot be determined precisely owing to the strong absorption.

The other constituents are little crystals of finely lamellated plagioclase, irregular grains of an untwinned felspar, apparently orthoclase, shapeless granules of opaque iron ore, and a little clear quartz occurring interstitially among the hornblende and other minerals.

(iv.) *Quartz-Diorite from Viti Levu, Fiji.*

This rock occurs in the cutting for a new road on the mountains to the south of the Wainamala valley, below Narokorokoyawa in the island of Viti Levu. It was collected by Mr. J. J. Lister during the voyage of the "Egeria" in 1889. It is a crystalline rock showing lustrous black crystals of hornblende, about a quarter of an inch long, and flakes of golden-brown mica, in a mass consisting mainly of felspar. The specific gravity is 2·778.

Sections [1256, 1257] show that the felspar is exclusively plagioclase, in idiomorphic crystals, in which the usual albite-lamellation is combined with Carlsbad and sometimes with pericline-twinning. A strongly marked zonary structure is apparent in polarized light, the extinction-angles being much wider in the interior than in the border. There is clearly a transition in each crystal from a thoroughly basic to an intermediate felspar. The hornblende, often twinned, is of the green pleochroic variety found in the syenites and most true diorites, and the mica (biotite) is brown with intense dichroism. These two minerals are often closely associated, and, for the most part, mould the felspar. Quartz occurs interstitially as the latest product of consolidation. The earliest-formed minerals are apatite and magnetite, which are enclosed by all the other constituents.

The specimens are quite fresh, and, as regards the mutual relations of the minerals, the zoning of the felspars, etc., agree well with some examples of the Banatite type of quartz-diorite, such as those from Hodrics near Schemnitz [1085] and from Ben Nevis [397], or some of the Banat rocks themselves. Wichmann,[1] in his account of the Fiji rocks, has described a diorite from near the same locality; but it is clearly of a different type, and he makes no mention of either quartz or mica.

(v.) *Uralitized Gabbro from Eua, Tonga Islands.*

This specimen, also from Mr. Lister's collection, is from a boulder on the east coast of Eua, but the position in which it occurs proves that it must belong to the island itself. The point is one of some interest, as Eua, like the rest of the group, appears at first sight to be built entirely of volcanic and calcareous rocks. The rock is a

[1] Tsch. Min. u. petr. Mitth. (n.s.) vol. v. p. 17; 1883.

moderately fine-grained cystalline aggregate, in which little patches of black hornblende are seen moulding the dull whitish felspars.

In a slice [1258] the felspar is seen to be a lamellated plagioclase in crystal-plates, idiomorphic towards the bisilicates, but interfering with one another. Some crystals have their zones of growth indicated by slight differences in optical properties. The wide extinction-angles point to a basic composition. The hornblende has a pale green-brown colour, with a fibrous structure. It is sometimes a mass of matted fibres, though more usually there is a common orientation throughout each plate. There is no doubt that the mineral is pseudomorphic after augite, and there is frequently an unaltered kernel of colourless augite in the centre of the uralitic aggregate. In places, however, the usual amphibole cleavage is seen, and this is accompanied by more pronounced colour and pleochroism. The only other prominent mineral is magnetite, in irregular patches, of later formation than the felspar, but moulded by the bisilicate. The structure of the rock points to a plutonic origin, the general characters being those of a gabbro rather than a diabase, though to some extent transitional.

V.—Notes on the Older Rocks of Finland.

By R. N. Lucas, B.A.

(*Continued from page* 299, Vol. VII. July, 1890.)

THE consideration of the Archæan rocks of Finland, as pointed out in a previous article,[1] naturally divides itself into two parts: I. The treatment of the stratified or foliated members of the series; II. That of the igneous or eruptive rocks. In describing the former, want of space compelled me to handle the subject in what I fear must be regarded as a very fragmentary manner. In addition I confined myself entirely to giving an account of the older members of the formation, omitting all mention of the younger schists, mica-clay slates, phyllites, etc., which go to make up what is in Finland regarded as corresponding to the Huronian subdivision. I did this from two reasons,—firstly, because I was personally better acquainted with the rocks in question; secondly, because it seemed to me that it is the problem of the origin, sequence and composition of the *older* members of the series which at the present day possesses most interest for the student of the geology of the Archæan, and in consequence is the one with regard to which the greatest divergence of opinion prevails. In the present article I propose to give a short account of the more important eruptive rocks of Finland; but before proceeding to do so, it would not, I think, be out of place to furnish a short *résumé* of the conclusions to which the study of the foliated Archæan rocks of the country has led me, and which I believe to be thoroughly supported by the data published in my former article. These are:—

1. The succession on which I especially insist, namely, commencing from the base—(1) Granite-gneiss; (2) Grey micaceous gneiss;

[1] Geol. Mag. July, 1890.

(3) Hornblende-gneiss or eurite. This sequence corresponds with that which has been established by Gümbel in Saxony, by the official survey in Sweden, by Groth in the Central Vosges (Geog. Unt. des Reichslands), and recently by Prof. Bonney in Switzerland. A similar sequence does not as yet appear to have been established among the Archæan rocks of the British Isles; but this may be due to local causes or to its having hitherto escaped the notice of geologists.

2. That the Archæan rocks of Finland present a similarity—I might I think almost say identity—of structure and composition with those of all true Archæan territories, whether situated in Switzerland or Scandinavia, Canada or Saxony.

3. That though we meet with numerous instances of gneisses which have been crushed and contorted, we also find plenty of examples which show no evidence of excessive pressure, and are nevertheless in all respects typical gneisses. This is particularly the case with regard to granite-gneiss and hornblende-gneiss.

4. That many, if not all, of the crystalline limestones which occur apparently interbedded with granite and gneiss, and in some of which "Eozoon Canadense" was formerly asserted to occur, are not deposits but veins, and are properly speaking to be classed with pegmatites and metallic lodes.[1]

Such are, I think, the principal conclusions to which a careful examination of the Finnish Archæan rocks conducts. They may, I trust, prove of interest not only because they summarize the results of research in a distant country, but also because, owing to the similarity of the Archæan system at all points where it has been observed, they may be regarded without hesitation as applicable beyond the limits of the district from the study of which they have, in the first instance, been derived.

Eruptive Rocks.

In my former article I massed both foliated and eruptive rocks together under the general heading of Archæan. This procedure is both convenient and customary, but it must be understood that its adoption involves the making of assumptions only some of which are in accordance with facts, others being actually controverted by them. Thus to regard the crushed and foliated granites which are interbedded with the older gneisses as of similar age with those gneisses themselves is a view which, as far as I am aware, there is nothing to disprove. But to consider all the eruptive rocks which pierce the gneiss formation as of Laurentian or even Archæan age, is an opinion which it seems to me there is not only nothing to support, but even the strongest presumptive evidence to disprove. Examples of this are afforded by the rapakivi, which in Southern and Western Finland occurs penetrating older strata, and might, if it had only been observed in those two districts, be regarded as of

[1] Instances in point are afforded by the limestones of Hoponsuo and Henriksnäs, in which the Russian geologist Pusirewski—one of the worshippers of "Eozoon"—formerly believed himself to have discovered the object of his adoration!

Laurentian age. In the neighbourhood of Joensuu, however, a rock corresponding in all respects to the rapakivi of the south and west, was discovered by Prof. Wiik contorting and dislocating Huronian slates and phyllites, and hence it has become customary to consider the rapakivi as a "younger" eruptive rock. The case of the diabases is very similar. No grounds could be advanced which would lead to the conclusion that the dykes and bosses of the north of Ladoga Lake (Wallamo) are much more recent than the Huronian period. But in the extreme west of Finland a strip of sandstone occurs which is usually regarded as Cambrian, and this sandstone is pierced by diabase dykes. There is a strong family resemblance between nearly all the Finnish diabases, and it would certainly not be a very violent hypothesis to look upon them all as approximately of the same age, *i.e.* Cambrian or later—how much later we cannot form even an approximate opinion, as in Finland there is a "Gonungagap" from early Cambrian to Quaternary times.

I now pass to the consideration in detail of the more important igneous rocks following the natural subdivisions of the subject, and commencing with a description of—

1. The Acid Eruptive Rocks.

Gneiss-Granite.—The base of the crystalline series we found to consist of the *granite-gneiss*—a rock in which coarseness of banding and indistinctness of foliation cause it to present a *superficial* resemblance to granite. In the gneiss-granite we have a granite which, through the influence of pressure, shearing-stress, or other causes, has assumed the appearance of a fissile gneiss, and which might be very appropriately termed a foliated granite. In many instances it appears to be the oldest member of the eruptive series; for in most cases where it is pierced by unaltered granite, the latter is plainly a younger rock. I think, however, it would be incorrect to assume that all gneiss-granites are of the same age, for I have seen plenty of evidence to make me incline to the opinion that gneiss-granite is in reality a *facies* assumed by granites which may differ in age. Among other reasons for thinking this to be the case, I may mention that I have most distinctly observed at least one case in which a boss of granite which was mineralogically homogeneous throughout, showed unmistakeable foliation near its edges, which became less distinct and finally disappeared on approaching the centre of the mass. This, I think, can only be explained by assuming that pressure and shearing-stress have made their influence more felt upon the exterior portions than upon the interior.

Statigraphically the gneiss-granite usually preserves relations of more or less intimacy either with the granite-gneiss or with the grey gneiss, running side by side with one or other of these rocks over considerable tracts of country. Its foliation always appears parallel to the strike of the gneisses—a fact which certainly favours the view that it was the same pressure which tilted the gneiss strata into their vertical position which produced the foliation of the granite.

That in spite of its foliation it is of eruptive origin is very well shown by the fact that where it has gneiss for its next door neighbour, the latter rock becomes impregnated with granite-magma, which, as the gneiss-granite is the only granite near, cannot have been derived from any other source. It is often said to pass into ordinary non-foliated granite of a mineral composition identical with its own. I feel very little doubt, however, that in many cases in which this is stated to have been observed, and which I have not myself seen, the facts are in reality similar to those in the instances I gave above, namely, that the whole mass is one granite, foliated externally, and losing its foliation inwards.

Cases occur in which the gneiss-granite is pierced to such an extent by bosses and veins of *massive* (unsheared) granite, doubtless of later age, that it becomes a matter of difficulty to decide which of the two rocks in reality predominates. This state of things prevails in the neighbourhood of the village of Nummis.

Petrographically the gneiss-granite consists, like ordinary granite, of quartz, felspar, and mica. The quartz and felspar are as a rule disposed quite irregularly throughout the mass of the rock, but the mica occurs in laminæ which show parallelism of arrangement, giving rise to a semi-schistose, at times fissile appearance. Thus the apparent foliation of the rock is due entirely to the mica, and if we could dissolve it out or eliminate it by any other means, we should as a rule obtain a structureless mass of felspar and quartz. It is consequently the mica which enables us to distinguish gneiss-granite both from ordinary massive granite and from granite-gneiss. In the former no order of arrangement whatever is observable among the minerals composing it. In the latter there prevails a certain parallelism of arrangement among all the minerals of which it consists, and this would still remain to be observed even if any one of them such as the mica were to be removed. In addition true gneiss nearly always displays more or less stratification which is entirely absent in the case of gneiss-granite, for the latter quite resembles typical massive granite in its petrological uniformity and sameness of colour over wide areas.

Occasionally a certain subsidiary parallelism of mica cutting the principal mica planes at an angle is observable. This appearance we may, I think, correctly attribute to secondary stresses—it is in fact the outward and visible sign of secondary cleavage.

There is also a curious variety of gneiss-granite in which the rôle ordinarily played by the mica is assumed by the quartz. In these cases the quartz individuals are found as a species of laminæ arranged parallel to the general direction of cleavage and contributing to it (Mantsila district). Where the quartz occurs in this manner, the mica no longer shows parallelism—on the contrary, the mica and the felspar are then disposed quite irregularly throughout the whole.

Rapakivi, Sheet No. 7.—The towns of Borgå and Friedrikshamn are situated in the Gulf of Finland, about 70 miles apart. A square erected upon a line joining the two would, roughly speaking, comprise the celebrated Rapakivi district of the South of Finland. The

whole of this region is comparatively flat in character, consisting of round dome-shaped protuberances covered with wood and alternating with lakes and shallow valleys above the level of which they seldom rise to a distance of more than about 50 or 100 feet. With the exception of a few dykes and bosses of younger granite and syenite, rapakivi forms the fundamental rock throughout the whole of this district, and there is scarcely a hillock or elevation where it is not to be seen emerging from beneath the Post-Tertiary formations which frequently overlie it, and presenting to the view the large crumbling boulders from which the rock has derived its name—rapakivi meaning in Finnish rotten or crumbling stone. The aspect of these boulders is very peculiar, at times picturesque; on the weather-side they have not unfrequently crumbled away to what is obviously not more than half their original size, and the base of the rock is in consequence covered with a talus of weathered fragments of felspar quartz-grains, hornblende crystals, etc., among which the large egg-shaped balls of orthoclase, varying from about an inch in diameter to the size of the fist, are still to be found comparatively intact.

Petrographically rapakivi consists of an aggregate of quartz, orthoclase, biotite and hornblende—the last being always in evidence. The orthoclase varies from pink to brick-red, occurring as a rule in crystals of 1½in. to 2½in. long and 1in. to 2in. thick, with glassy principal cleavage often appearing as Carlsbad-twins, and forming the principal constituent of the rock. Owing to radial accretion, it often happens that the crystals assume the form of oblong spheres which occur notably in the neighbourhood of Elima. These large crystals of orthoclase are surrounded by a mantle of oligoclase of a yellowish-green colour turning white on weathering. The quartz crystals, which are smoky grey or white, average about ½in. in diameter. The mica, which is extremely black, is pretty equally distributed throughout the whole in the form of brilliant laminæ. The hornblende, which is black, occasionally turning somewhat green, occurs only in small quantities and in the form of short monoclinic prisms. The rock does not display the slightest tendency towards parallel arrangement of any of its constituents.

Rapakivi has been microscopically examined by H. Gylling, from whose report the following facts are taken.

"In addition to orthoclase and oligoclase, microclinic felspar also occurs, recognized by its peculiar structure and the fact that it extinguishes polarized light 14° to 15° from the edge between the clinopinacoid[1] and the basal plane. The microscopic examination further shows that the quartz crystals are sometimes fully crystallized out and contain water in minute cavities (fluid inclusions). Both hornblende and oligoclase are much weathered, the former occasionally being decomposed into calcite. As occasional constituents occur yellow and yellowish-brown prisms of zircon, red laminæ and needles of hæmatite, and black opaque masses of magnetite

[1] It will be seen that microcline is here regarded as really monoclinic—an opinion with which I certainly agree.

and titaniferous iron ore. Crystals of fluor-spar are also at times visible even to the naked eye."

Though as above pointed out the rapakivi is almost perfectly uniform in its characteristics throughout the district in which it occurs, a variety distinguished by comparative hardness and capacity for resisting the weather is also found, as a rule on the confines of the rapakivi region proper; for instance, in Morsköm, Perno, and Borgå parish, where, as also in Helsingfors, it is largely used as a building-stone. In this variety there is usually less oligoclase and hornblende, and the orthoclase and quartz crystals are of larger size.

The remarkable tendency to fall to pieces under the action of the weather, which, if we except the occurrence of microcline, is perhaps the most characteristic peculiarity of rapakivi, has given rise to a variety of attempted explanations. Some have inclined to the opinion that the phenomenon in question is due to the presence of iron. A strongly weathered rapakivi from Lappträsk, however, was found to contain 7·62 per cent. of iron, while an unweathered sample from Elima gave as much as 6·53 per cent.—a difference in amount hardly sufficient to explain the observed variations in behaviour towards the weather. Others again attribute the opposite effects observed in the two varieties to the different proportions of silica. Here are some analyses bearing upon the question :—

	Silica.
A non-weathered rapakivi from Strömfors	67·44
A similar rapakivi from Elima	69·17
Rapakivi from Korsmalm, near Lappträsk, much weathered	77·61

There seems, however, to be no reason why a high percentage of silica should conduce to weathering, and it does not always appear to be the case that the weathered specimens contain more silica than the unweathered. Probably Moberg is right in attributing the principal rôle in the matter to the oligoclase which weathers easily and occurs in greater amount in the weathered samples.

At a few places within the rapakivi territory it is pierced by dykes of a younger granite consisting mainly of orthoclase and quartz as at Norrby, near Lappträsk.

Rapakivi is everywhere very much jointed and the jointing takes place in certain regular directions.

This peculiar rock is, as is well known, confined exclusively to Finland, with the exception of the boulders which were transported thence to the North German Plains by the agency of ice during the Glacial Period, where they are to be met with very frequently and have been elaborately described by v. Ungern Sternberg (N. Jahrb. f. Min. 1882).

There is another rapakivi district in the West of Finland, in the neighbourhood, namely, of Nystad. Here the rock differs a good deal from the southern and more characteristic type described above. The structure there so common, according to which the orthoclase balls are surrounded by a sort of mantle of oligoclase, is here seldom observed. On the contrary, the orthoclase usually occurs in separate crystals of considerable dimensions, and the

general matrix of the rock surrounds the balls or nodules of orthoclase without any intermediary concentric oligoclase layer.

Microscopically it differs also from the other variety in being destitute of microcline. It occasionally shows micro-pegmatitic structure; and its quartz is peculiar, being very idiomorphically developed and containing long needles (microliths) of a dark-coloured mineral which the American geologist Hawes declares to be rutile.

In its stratigraphical relationships the western rapakivi is very interesting, a great deal of evidence having been collected tending to show that it has both exercised an enormous pressure on the rocks through which it has been forced, and has itself in places been modified by this pressure, which may perhaps justify the assumption that it was in a very pasty condition when irrupted. The southern rapakivi on the contrary does not appear to have modified the surrounding rocks at all.

Great masses of granite, syenite, and elæolite-syenite occur throughout the country; but as they do not on the whole differ from similar rocks in other districts, I have not devoted any space to a description of them.

The various questions relating to the origin, characteristics and occurrence of pegmatites, I propose to reserve for future consideration.

NOTICES OF MEMOIRS.

Three Papers on Graptolites.

1. Ueber das Alter des sogen. Graptolithen-Gesteins mit besonderer Berüchsichtigung der in demselben enthaltenen Graptolithen. Von Herrn Otto Jaekel, in Berlin. Zeitschr. d. deutschen geolog. Gesellschaft, Jahrg. 1889, pp. 653–716, Taf. xxviii. xxix.
2. Gotlands Graptoliter. Af Gerhard Holm. Bihang till K. Svenska Vet.-Akad. Handlingar, Bd. 16, Afd. iv. No. 7 (1890), pp. 1–34, Taf. 1, 2.
3. Undersökningar öfver Siljansområdets Graptoliter. Af Sv. Leonh. Törnquist. Lunds Univ. Årsskrift. Tom. xxvi. pp. 1–33, Taf. i. ii.

1. On the Age of the so-called Graptolite Stone, with Special Reference to the Graptolites contained therein. By Otto Jaekel.
2. The Graptolites of the Island of Gotland. By Gerhard Holm.
3. An Examinaton of the Graptolites of the District of Siljan, Dalarne, Sweden. By Sv. Leonh. Törnquist.

SCATTERED through the Drift of Northern Germany there are numerous boulders of calcareous rock containing, with various other fossils, several species of Graptolites, and for this reason they were styled "Graptolithen-gestein" by Ferd. Roemer. The parent-rock of these boulders, situated somewhere in the Silurian basin of

the Baltic, has not yet been discovered, and different opinions have been expressed as to the particular divisions of the Silurian to which the boulders belong. By the majority of German geologists they have been referred to the highest series of the Silurian ; the Swedish geologists on the other hand place them about the middle of the Upper Silurian series. With the view of elucidating the question, Dr. Jaekel has examined the Silurian outcrops in the West of England, and he finds that there is a very close correspondence both in the petrological characters and the fossils of these boulders with the beds of Wenlock Shale age exposed at Burrington, near Ludlow, and therefore he maintains that they really are of the age of the Wenlock Shale.

In the present paper the characters and the geological distribution of the fossils in the boulders are treated of, but the author more particularly refers to the Graptolites, and brings forward some new structural features which in his opinion will considerably modify their present classification. Thus in the genus *Monograptus*, two groups are proposed, based chiefly on the different position of the thecal aperture and its appendages. In the first of these, *Pristiograptus*, the aperture is free, and occupies the entire upper end of the theca, and the only appendages are spines on the lower margin of the aperture, and these are not always developed. In the second group, *Pomatograptus*, the outer portion of the theca is contracted, the aperture is small and situated beneath an extended roof-like process which forms the upper end of the theca. Hitherto the thecal aperture in these Graptolites has been supposed to be at the extreme end of this arched process, but the well-preserved examples figured by Dr. Jaekel show that this view is erroneous.

The author further maintains that Graptolites were not free-swimming organisms, but probably lived at the bottom of deep seas lightly anchored in the mud. He also considers that the simple forms of *Monograptus* are not complete, but only branches of colonial stocks; but, as pointed out by Dr. Holm, he seems to have overlooked the fact of the presence of the sicula, which is never wanting at the proximal end of the organism, and thus conclusively shows the primary commencement of the growth of the polypary. A description of the structure of *Retiolites* is likewise given, but in this no account is taken of the earlier works of Törnquist and Tullberg.

In the second paper above mentioned, Dr. G. Holm has revised the list of Graptolites occurring in the Silurian strata of the Isle of Gotland, and enumerates the following nine species and varieties; *Dictyonema cervicorne*, n. sp., *D. abnorme*, n. sp., *Monograptus priodon*, Bronn, *D. priodon*, var. *Flemingii*, Salt., *M. subconicus*, Törnq., *M. dubius*, Suess, *M.* sp., *Retiolites Geinitzianus*, Barr., and *R. nassa*, n.sp. A list is given of the names and distribution of the known species of *Dictyonema*, and a very careful description of a new species, *D. cervicorne*, based on specimens obtained free from matrix. In these the upper portion of the theca is extended into a long, spined process bifurcated at the extremity; and connected laterally with each theca there is a cup-like or nest-shaped structure, possibly a

gonangium. Dr. Holm further describes and figures some remarkably well-preserved examples of *Retiolites* and *Stomatograptus*, in which the structural details are clearly shown.

In the third paper, Professor Törnquist describes 22 species of Graptolites occurring in the Ordovician and Silurian strata of the district of Siljan; of these the following are regarded as new, *Clonograptus robustus*, *Tetragraptus curvatus*, *Didymograptus gracilis*, *D. decens*, *Climacograptus internexus*, and *Diplograptus bellulus*. Many of the species in the area referred to are likewise common to the Coniston Flags and to the Quebec Group of Canada.

REVIEWS.

L'Archéen et le Cambrien dans le Nord du Massif Breton et leurs équivalents dans le Pays de Galles. Par A. Bigot, Docteur-ès-Sciences. (Cherbourg, 1890.)

DOCTOR BIGOT is a young French geologist who is rapidly winning his spurs. Having done excellent work amongst the older rocks of Northern France, he came over to Great Britain, and compared the systems with which he was familiar with some of the basal rock-groups of Wales and Shropshire. The results of this comparison are given in the work before us, and will be found to be in substantial agreement with the views maintained by those who in this country have paid the fullest attention to the Archæan and Cambrian rocks.

In the first part of his work Dr. Bigot describes the phyllads and purple conglomerates in the district of Saint-Lô and in the west of Calvados. From the typical area, he passes to the northern extension of these formations, as studied in the district round Cherbourg. He then takes up the same rock-groups south of Saint-Lô, and describes their occurrence in the south of Calvados, at Granville, and in the island of Jersey, which lies about 30 miles to the north-west of Granville. In Chapter IV. the author discusses the relation between the Phyllads and the older Palæozoic groups. Chapter V. gives an account of the eruptive rocks of Normandy and the Channel Isles; and Chapter VI. concludes the first part with a description of the general stratigraphy of the Breton *massif*. In the succeeding chapters the author discusses the correlations of the older rocks of north-western France with their equivalents in Pembrokeshire, North Wales, and Shropshire; and winds up with an excellent summary of his conclusions. Then follows a valuable bibliographic index, the authors being classed under the respective heads of "The Breton *massif*," and "Wales" (including Shropshire).

The schistose and slaty rocks named after the town of Saint-Lô, and usually referred to by French geologists as "schistes" or "phyllades," have been described by a long series of writers. Dufrénoy in 1838 identified them with the Cambrian of Great Britain, a very natural opinion at a time when the Longmynd series was accepted as typical Cambrian, and when the existence of slaty rocks below the Cambrian was not recognized in Europe.

Dufrénoy's identification was accepted by Dalimier, Bonissent, De Lapparent, and finally by Barrois, though it should be remarked that the last-named writer has been wont to quote Dufrénoy's opinion without positively endorsing it. Professor Hébert, however, adopting a Cambrian age for the "Conglomérats pourprés," and observing that these strata were unconformably superimposed upon the "Schistes de Saint-Lô," concluded that the latter were of Archæan age. In this opinion, the late Professor of Geology at the Sorbonne has been followed by his pupil, Dr. Bigot.

The evidence given in the volume before us would seem to be decisive of the true relation of the Saint-Lô Series to the purple conglomerates. The author confirms the existence of the stratigraphical discordance alleged by Hébert, and he affirms that the newer series contains pebbles of the sandstone which is intercalated amongst the Phyllads. The unconformity would therefore seem to be very marked.

The researches of Dr. Ch. Barrois and Dr. Bigot have brought to light additional resemblances between the rocks of Saint-Lô and the younger Archæans of Britain. According to the former writer, the Saint-Lô Series sometimes presents a volcanic facies. In the north of Brittany, acid rocks, such as "quartz-porphyries and petrosilex," are said by him to be interstratified with the Phyllads, and to furnish rounded fragments to the Conglomerates of Montfort, the equivalents of the "Conglomérats pourprés." Dr. Bigot records similar facts. He states that, at La Hogue and in the island of Alderney, the "purple conglomerates" contain pebbles of "petrosiliceous porphyries," evidently derived from an older formation.

According to Dr. Bigot, the district of La Hogue furnishes still more emphatic proof of the gap between the Phyllads and the purple conglomerate. A quarry displays a section of the Phyllads, penetrated by numerous veins of "granulite," and surmounted by the purple series. The veins are described as modifying the Phyllads, but producing no effect upon the purple beds; and it is inferred by Dr. Bigot that the older group was invaded and metamorphosed by the granite previous to the deposition of the purple conglomerates.

We are gradually learning that the resemblances between the newer Archæan rocks in Northern France and Western Britain are very close indeed. In the British area, the predominating types of rock in the Pebidian (or Uriconian) are acidic volcanic eruptives, hypometamorphic schists, grits more or less altered, and comparatively unaltered slates; and these are precisely the lithological characters most conspicuous in the Phyllads of Saint-Lô. The present writer accompanied Dr. Barrois and Dr. Bigot in the year 1888 to Caer Caradoc. Both of these geologists were struck with the lithological similarities between our Uriconian and the volcanic rocks associated with the Phyllads, and they have recorded their impressions in subsequent publications.

But the parallelism between the older rock-groups of the French and British areas has been shown to extend yet further. Dalimier,

in 1861, and Bonissent, in 1870, recorded the occurrence of conglomerates intercalated in the Phyllads. Barrois, in 1884, gave a list of the contained pebbles, amongst which was a "granite identical with that of Chausey." Hébert, subsequently (1886) described this conglomerate, also identifying the Chausey granite amongst the pebbles, and he concluded that the conglomerate proved the existence of granites "older than the Archæan," the term "Archæan" by this writer being limited to the group called by us "Pebidian" or "Uriconian." Bigot supports Hébert's contention, and carefully distinguishes "the conglomerates of Granville, with pebbles of granite, intercalated in the vertical Phyllads" from "the purple conglomerates, almost horizontal, forming the base of a series which the *Grès Armoricain* conformably overlies," that is to say, he makes the former conglomerate Archæan, and the latter Cambrian.

The conglomerate of Granville strongly suggests the Archæan conglomerate, which, at Charlton Hill near the Wrekin, contains pebbles of a granite which is undistinguishable from a granite exposed in the Wrekin and at Malvern; and, if Hébert and Bigot are right in their reading of the Granville section, a granite of Pre-Uriconian age is proved in both the British and French areas.

Whether the Phyllads of Saint-Lô represent only the Pebidian (Uriconian) of Britain, or also include the equivalent of the Longmyndian, is at present an unsettled question. A small collection of typical specimens from the Phyllads, sent some years ago by Prof. Hébert to the present writer, would be considered thoroughly typical of our Pebidian, and not at all like our Longmyndian.

The rocks which unconformably overlie the Phyllads are considered by Dr. Bigot to represent the several horizons of our British Cambrian. In the following table he indicates the parallelism which he believes to subsist between the members of the older systems in the two areas.

Wales.	Normandie.
Arenig.	Grès armoricain.
Olenidian.	Grès feldspathiques.
Solva and Menevian.	Schistes verts et grès verts.
Caerfai.	Schistes rouges et marbres.
Conglomerate.	Poudingues pourprés.
Pebidian.	Schistes de Saint-Lô.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Feb. 20, 1891.—Annual General Meeting.—Dr. A. Geikie, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1890. In the former the Council once more congratulated the Fellows upon the continued prosperity of the Society, as evinced by its increasing number and by the satisfactory condition of its finances.

The number of Fellows elected during the year was 76, of whom 56 qualified before the end of the year, together with 16 previously elected Fellows, and these, with one Fellow readmitted, made a total accession of 73 Fellows during 1890. As, however, from this number a deduction of 43 was made for losses by death, resignation, and removal, and for new Fellows compounding, the actual increase in the number of Contributing Fellows was 30. The total number of Fellows, Foreign Members, and Foreign Correspondents at the close of the year 1890 was 1405.

The Balance-sheet for the year 1890 showed receipts to the amount of £3034 8*s.* 1*d.*, and an expenditure of £2429 16*s.* 2*d.* Further, a sum of £420 10*s.* was expended in the purchase of stock, and the balance in favour of the Society at December 31, 1890, amounted to £433 17*s.* 6*d.*

The Council's Report also referred to the publication of the late Mr. Ormerod's Third Supplement to his Index to the Publications of the Society, to the editing of Nos. 183 and 184 of the Journal by Prof. T. Rupert Jones, to the deaths of the late Foreign Secretary and the late Assistant-Secretary, and in conclusion enumerated the awards of the various Medals and Proceeds of Donation-Funds in the gift of the Society.

The Report of the Library and Museum Committee included a list of the additions made during the past year to the Society's Library, and announced the completion of the glazing of the Inner Museum.

In presenting the Wollaston Medal to Prof. J. W. Judd, F.R.S., the President addressed him as follows:—

Professor Judd,—The Council have awarded to you the Wollaston Medal in recognition of the important services rendered by you to Geological science, especially in the department of Petrography. In recalling for a moment the value and extent of these services, I am reminded that, after showing your powers by an excellent paper on the strata of the Lincolnshire Wolds, you began your geological career in the Geological Survey under Murchison, and that you had thus a favourable opportunity of acquiring that practical acquaintance with the details of geological structure which can in no way be so thoroughly mastered as by actual patient mapping. Your volume on the "Geology of Rutland" proved how well you had profited by the advantages which your official duties afforded you. From the Jurassic rocks of England, which you had studied in minute detail, you were led to undertake the investigation of those of Scotland, which you succeeded in reducing to order, bringing them into closer relationship with their equivalents in the southern part of the United Kingdom.

It was in the course of those northern expeditions that you were drawn from the field of stratigraphy into the study of volcanic rocks, to which you have since devoted so large a part of your time and thought, and in the study of which you have journeyed far and wide in this country, and have extended your travels to the islands of the Mediterranean. The problems presented by these rocks in the field led you to seek the aid of the microscope, and to enter upon a course of distinguished petrographical research. I trust that the award of this Medal will be received by you as a mark of the estimation in which your work is held by the Society in whose Quarterly Journal most of it has been published.

Prof. Judd, in reply, said:—Mr. President,—It is a source of legitimate gratification to the student of science, when a favourable judgment on his efforts is pronounced by his contemporaries and fellow-workers. In receiving this highly-prized mark of your approval, I would fain forget for one moment, if that were possible, how far the work—of which you have spoken in such graceful terms—falls in amount below my hopeful anticipations of the past, how it fails to reach the standard of excellence

of my cherished ideals. Any value which that work may be found to possess is undoubtedly due, in great part, to the fostering care of the Society which to-day so generously crowns my labours. To the Geological Society, in its corporate capacity, I am indebted for the reception and publication of the results of my studies; to individuals composing that Society I owe more than I can ever express, for kind sympathy, warm encouragement, and friendly aid; and to both Council and Members I shall always be deeply grateful alike for helpful suggestion and discriminating criticism.

In handing the Murchison Medal awarded to Professor W. C. Brögger, of Christiania, to J. J. H. Teall, Esq., M.A., F.R.S., for transmission to the recipient, the President spoke as follows:—

Mr. Teall,—The Council has awarded the Murchison Medal to Professor W. C. Brögger, of Christiania, and in asking you to transmit it to him I will request you also to convey to him an expression of the high estimation in which we hold his researches among the older rocks of Scandinavia. He is remarkable among the geologists of Europe for the great range of his acquirements. If we were to read only his descriptions of the Silurian fauna of Southern Norway we should, doubtless, believe him to be essentially a palæontologist. If we looked over his maps and sections of the Christiania district, we should think of him rather as an admirable stratigrapher and cartographer. If, again, we began with his account of the eruptive rocks and their zone of contact-metamorphism, we should conclude that his chief studies must have lain in microscopic and chemical petrography, of which he is so accomplished a master. Or, lastly, if we knew him only by such essays as his late paper on garnets, we should regard him as preeminently a mineralogist, gifted with rare originality. He has swept a full chord on the geological lyre, and every note sounds rich and true.

It gives me personally an especial pleasure to be the intermediary in conveying the award of the Council, for I have had the advantage of being conducted by Professor Brögger over some of his classic ground around Christiania, and I know from my own experience how accurate and exhaustive is the work: how courteous, genial, and helpful the man. He will, I trust, receive this Medal, bearing the likeness and the name of one of the great masters of British Geology, who was also a pioneer in the geology of Norway, as a pledge of our esteem and sympathy with him in the great work he has already accomplished, and in the long and brilliant career which we hope is still in store for him.

Mr. Teall, in reply, read the following communication received by him from Professor Brögger:—"I beg to express my hearty gratitude for the great and completely unexpected honour conferred upon me by the Council of the Geological Society in the award of the Murchison Medal.

"The Founder of this Medal, almost half a century ago, classified the Silurian rocks of the Christiania district, and pointed out their relations to the corresponding strata of Great Britain; so that, if the subsequent investigations of Norwegian geologists have furnished results of interest to the students of British Geology, this is only a slight repayment of an old debt.

"In ancient times the mountain-ranges of northern Great Britain and Norway were probably connected and, in the Quaternary period, the Scandinavian ice-sheet stretched across to England and deposited boulders of Norwegian rocks, some of which were derived from the Christiania district. Now, in recent times science has rebuilt the bridges which formerly connected the two countries, inhabited by closely related peoples of the Germanic race.

"It will be an object of special interest to me to contribute, as far as I am able, to the reconstruction of bonds of union between Great Britain and Norway, in grateful remembrance of the benefits which Norwegian geologists in general, and I myself in particular, have derived from the celebrated Geological Society of London.

"Allow me, in conclusion, to express the great satisfaction I feel at receiving this honour during the Presidency of so eminent a geologist as Dr. Archibald Geikie, who is personally acquainted with the geology of Norway."

The President then presented the Lyell Medal to Professor T. McKenny Hughes, F.R.S., addressing him as follows:—

Professor Hughes,—The Lyell Medal has this year been adjudged by the Council

to you in appreciation of the value of your investigations in various departments of Geology, especially among the older rocks. Your researches in Caernarvonshire and Anglesey formed the starting-point of those later inquiries which have done so much to clear up the earlier chapters of the geological history of Wales. You have not confined yourself, however, to the rocks of any one system or period, but have ranged freely from the Archæan gneiss to raised beach, hovering for a moment here and resting a little there, generally critical, almost always suggestive, and with that happy faculty of enthusiasm which, reacting on younger minds, "allures to older worlds, and leads the way."

As I place this Medal in your hands, I cannot but recall the days of our early friendship, now faded so far into the dim past of life, when, as colleagues in the Geological Survey, we used to attend the meetings of this Society in Somerset House, taking seats on a back row and gazing down upon the magnates of the science seated beneath. Little did either of us dream that the whirligig of time would eventually place us where we find ourselves to-day. It is thus no small gratification to me to be called upon to present to you this Medal, which will not only serve to mark the Society's appreciation of your work, but which will connect you by another link with the memory of our friend and master, Lyell.

Prof. Hughes, in reply, said:—Mr. President,—I feel that I have, as the senior, been selected to receive this high recognition of the work being carried on by the Cambridge School of Geology. I have not myself been able to offer much to the Society of late, save occasional criticism, but my colleagues, Mr. Marr and Mr. Harker, Fellows of the Society, whose opinions are regarded each year with increasing respect, the one your Secretary, the other on your Council, have from time to time contributed valuable papers, while my other colleague, Mr. Roberts, has also laid before the Society the results of important original observations made by him. The Society knows that it is chiefly to the lecture-room, the museum, and the field-classes that it must look for men to carry on its work in the future. But I must acknowledge in this respect also that the heaviest work has fallen upon my colleagues. They know, however, that in the administration of the Department, and directly and indirectly in promoting the cause of Science, I help as far as I can. We all work well together, and I feel that they will rejoice with me now, will help to carry back the Lyell Medal in triumph to Cambridge, and will join with me in offering to the Society our warmest thanks for the honour that has been done us. We shall regard it as a stimulus to follow in the steps of the great teacher whose name is commemorated on the Medal, and try always to distinguish clearly between what is proved, what is disproved, and what remains, however plausible, "not proven."

I am glad that it has fallen to my lot to receive this honour from the hands of an old and valued friend, upon whom has fallen the mantle of Lyell, a mantle in which the warp of science and the weft of literature are so deftly interwoven.

The President then handed the Bigsby Medal, awarded to Dr. G. M. Dawson, F.G.S., of Ottawa, to Dr. Hicks, F.R.S., for transmission to the recipient, and addressed him as follows:—

Dr. Hicks,—In asking you to transmit the Bigsby Medal to Dr. George M. Dawson, I request you to convey to him at the same time an assurance of how fully the Council appreciates the value of his researches into the geological structure of Canada, and how cordially we hope that he may live long to prosecute the explorations which have shed so much lustre on the Geological Survey of his native country.

Dr. Hicks, in reply, read the following communication, received by him from Dr. Dawson:—"Mr. President,—I have to express my high appreciation of the honour which you and the Council of the Geological Society have conferred upon me in the award of the Bigsby Medal.

"I regret that my official duties at the present time render it impossible for me to be present in person at the Anniversary Meeting to assure the Society of the high esteem in which I hold this mark of recognition.

"My field of geological work has laid chiefly in the further Western, and as yet imperfectly known, portions of the Dominion of Canada, and much of the work itself has been of an exploratory character, and only occasionally, and then to a limited extent, precise or finished. Work of this class, though necessary in the first instance, and possessed of the special interest attaching to any virgin field, must suffer by comparison with that obtained in the investigation of smaller areas,

and carried on under more favourable conditions. It is thus all the more gratifying and encouraging to me that such results as I have been able to obtain should be deemed worthy of the recognition of the Society.

"I may be pardoned for alluding to the fact that some of the earliest work in Canadian Geology is due to the personal efforts of the distinguished Founder of this Medal, in whose very footsteps it has at times been my privilege to follow. This, with the pleasant remembrance of advantages derived in former years from personal intercourse with Dr. Bigsby, and kindly advice received from him, tend to enhance, if possible, the sense of gratification felt by me in learning that my name has been added to the roll of those considered worthy to receive the Bigsby Medal."

In presenting the Balance of the Wollaston Fund to Richard Lydekker, Esq., B.A., F.G.S., the President said:—

Mr. Lydekker,—The Council has awarded to you the Proceeds of the Wollaston Donation Fund in recognition of the value of your numerous contributions to Vertebrate Palæontology. We trust that you will continue these investigations and that, whether they appear in the publications of this Society or elsewhere, the results, like those which have preceded them, may tend to the steady advancement of our favourite science.

Mr. Lydekker, in reply, said:—Mr. President,—The particular branch of Palæontology to which my own studies have been more especially directed is one which, from its nature, is so beset with difficulties that it is very apt to lead to misgivings as to whether any real good results from its pursuit. The assurance conveyed by the honour that the Council of the Society has conferred upon me, that such work as I have been able to do is not unappreciated, is therefore very gratifying.

Although circumstances have rendered it almost imperative that I should devote my time to literary work rather than to original scientific research, yet I still hope to do something in the latter field.

Please accept, Sir, on behalf of the Council, my thanks for the mark of distinction that they have bestowed upon me.

In handing the Balance of the Murchison Geological Fund (awarded to the Rev. Richard Baron, F.L.S., F.G.S., of Antananarivo) to Wm. Topley, Esq., F.R.S., for transmission to the recipient, the President said:—

Mr. Topley,—I have to request you to transmit to the Rev. R. Baron the Balance of the Proceeds of the Murchison Geological Fund, in testimony of the interest taken by the Council in the geological work which, amid so many discouragements, he is carrying on in Madagascar. We desire him to accept this Award as a mark of our hearty sympathy and of our wish to aid him in his researches.

Mr. Topley, in reply, said:—Mr. President,—On behalf of Mr. Baron, who is now in Madagascar, I beg to thank the Council and yourself for the honour conferred upon him in the award of the Murchison Fund. As a Missionary in an area as yet but little known, Mr. Baron has exceptional opportunities for original research, and that he has not neglected those opportunities is evident from his papers already read to this Society and to the Linnean Society. The Award now made will, I am sure, be an incentive to further work in a most promising field of research.

The President then handed one half of the Balance of the Lyell Geological Fund, awarded to Dr. C. J. Forsyth-Major, of Florence, to Dr. H. Woodward, F.R.S., for transmission to the recipient, and addressed him as follows:—

Dr. Woodward,—In requesting you to transmit to Dr. Forsyth-Major one moiety of the Balance of the Lyell Geological Fund, I wish to express the Council's appreciation of his researches and its hope that he will continue them. He has done much to increase our knowledge of the Pliocene Mammalia of the Val d'Arno, and he has recently extended his explorations among the younger Tertiary deposits of the Eastern Mediterranean.

Dr. Woodward, in reply, said:—Mr. President,—On behalf of Dr. C. J. Forsyth-Major, I have to acknowledge the honour conferred upon him by the Council of this

Society in awarding him a moiety of the Lyell Fund. The work to which Dr. Forsyth-Major has devoted his life so entirely accords with the researches and labours of Sir Charles Lyell that I cannot doubt the appropriateness of this Award.

Dr. Forsyth-Major has devoted many years to the elucidation of the Pleistocene and Pliocene mammalian faunas of the Val d'Arno and Northern Italy, and his numerous memoirs attest the value and accuracy of his work. Lately he has devoted two years to the exploration of the Pliocene fauna of the Island of Samos, and has obtained thence two very important collections (at present only partially examined)—one now in the Geneva Museum, the other in the British Museum (Natural History), Cromwell Road. Among these are a large number of forms specifically identical with the mammals from the equivalent deposits of Pikermi in Attica, Baltavar in Hungary, and Maragha in Persia; and also several new types of much interest as showing a former wider distribution for existing forms.

It is Dr. Forsyth-Major's hope to spend the early summer months in London, to complete his descriptions of these fossil remains, which your Award will doubtless assist him in doing.

He writes as follows:—"Would you kindly transmit to the President and Council of the Geological Society my grateful acknowledgments of the honour conferred upon me, which I value so much the more as coming from a scientific body of my own country, to which, owing to the fact that my family resides abroad, I have become nearly a stranger.

"If I rightly understand the intention of the Council, this Award is given less as a mark of their approval of what I have already done than as an incentive to future labours.

"In my palæontological work I have striven to follow the example of one of the masters of our science, the late Dr. Hugh Falconer, devoting myself more to the collecting of facts and observations than to their speedy publication. This reserve seems to be imposed upon us even more in our day than in that of Dr. Falconer's."

In presenting the other half of the Balance of the Lyell Geological Fund to G. W. Lamplugh, Esq., F.G.S., the President addressed him as follows:—

Mr. Lamplugh,—The Council, in awarding to you one-half of the Proceeds of the Lyell Geological Fund, desires to assure you of the estimation in which it holds your work, and of the pleasure it will derive from their further prosecution. Your researches among the Glacial deposits of Yorkshire have been followed with much interest, and we have rejoiced in the enthusiasm which not only carried you through these labours at home, but which impelled you to seek the solution of some of your difficulties by journeying to the far distant shores of British Columbia. Your investigation of the Specton Clay affords a striking example of how our knowledge may be corrected and extended by the patient labours of an observer resident on the spot which he has to examine. I hope you will accept this Award with the best wishes of the Council and of the Society.

Mr. Lamplugh, in reply, said:—Mr. President,—That I should have been selected by the Council to receive this Award affords me the greatest encouragement, since it comes to me as a token that my geological work, in spite of its narrow and local character, has after all a certain value.

It is scarcely possible that any one who has any sympathy whatever with Nature should spend much time on the Yorkshire coast without becoming more or less of a geologist, and for my own part I drifted almost unconsciously into these studies in my boyhood, and have ever since found therein my happiest and healthiest recreation. My pleasure in them is now redoubled by this proof that the time so happily spent has also been spent usefully.

I thank you, and hope that, as a coastguard in the service of science, I may still occasionally be able to send to headquarters reports which may contain some items of interest.

The President proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Fellows, Foreign Members, and Foreign Correspondents deceased since the last Annual Meeting, including the late Foreign Secretary Sir Warington W. Smyth,

the late Assistant-Secretary Mr. W. S. Dallas, M. Edmond Hébert and M. Alphonse Favre (Foreign Members, both elected in 1874), Mr. Wm. Davies, Mr. Robert Wm. Mylne, Mr. Samuel Beckles, Dr. H. B. Brady, Mr. Samuel Adamson, and Prof. Antonio Stoppani (Foreign Correspondent, elected in 1889).

He then dealt with the history of volcanic action in Britain during the earlier ages of geological time. He proposed to confine the term "Archæan" to the most ancient gneisses and their accompaniments, and showed that these rocks, so far as we know them in this country, are essentially of eruptive origin, though no trace has yet been found of the original discharge of any portion of them at the surface. Passing to the younger crystalline schists, which he classes under the term "Dalradian," he pointed to the evidence of included volcanic products in them throughout the Central Highlands of Scotland and the North of Ireland. The Uriconian series of Dr. Callaway he regarded as a volcanic group, probably much older than the recognized fossiliferous Cambrian rocks of this country. The Cambrian system he showed to be eminently marked by contemporaneous volcanic materials, and he discussed at some length the so-called pre-Cambrian rocks of North Wales. He reviewed the successive phases of eruptivity during the Arenig and Bala periods, and described the extraordinary group of volcanoes in Northern Anglesey during the latter time. The volcanoes of the Lake District were next treated of, and reference was made of the recent discovery by the Geological Survey that an important volcanic group underlies most of the visible Lower-Silurian rocks in the South of Scotland. The last portion of the Address was devoted to an account of the volcanoes of Silurian time in Ireland, and it was shown that during the Bala period a chain of submarine volcanic vents existed along the east of Ireland from County Down to beyond the shores of Waterford; while in Upper-Silurian time there were at least two active centres of eruption in the extreme west of Kerry and in Mayo.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*Council*: Prof. J. F. Blake, M.A.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; James Carter, Esq.; James W. Davis, Esq., F.L.S., F.S.A.; John Evans, D.C.L., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; C. Le Neve Foster, D.Sc., B.A.; A. Geikie, LL.D., F.R.S.; A. Harker, Esq., M.A.; J. C. Hawkshaw, Esq., M.A.; H. Hicks, M.D., F.R.S.; G. J. Hinde, Ph.D.; W. H. Hudleston, Esq., M.A., F.R.S.; Prof. T. McKenny Hughes, M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; J. E. Marr, Esq., M.A.; H. W. Monckton, Esq.; F. W. Rudler, Esq.; J. J. H. Teall, Esq., M.A., F.R.S.; W. Topley, Esq., F.R.S; Prof. T. Wiltshire, M.A., F.L.S.; H. Woodward, LL.D., F.R.S.

Officers.—*President*: A. Geikie, LL.D., F.R.S. *Vice-Presidents*: W. T. Blanford, LL.D., F.R.S.; Professor T. G. Bonney, D.Sc., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; W. H. Hudleston, Esq., M.A., F.R.S. *Secretaries*: H. Hicks, M.D., F.R.S.; J. E. Marr, Esq., M.A. *Foreign Secretary*: J. W. Hulke, Esq., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S.

CORRESPONDENCE.

THE SAIGA ANTELOPE IN BRITAIN.

SIR,—In the February Number of the GEOLOGICAL MAGAZINE, p. 94, is a notice of the discovery of the horns of the Saiga Antelope in the Thames Gravels at Twickenham. An earlier discovery was, however, made some years ago of this northern animal by the late Mr. R. W. Mylne. The specimens, which consisted of two horn-cores, were shown by him to me, and I submitted them to Mr. G. Busk, who pronounced them to belong to the Saiga Antelope. Unfortunately Mr. Mylne could not say where they came from. He thought from the neighbourhood of Bedford, and said he would make further inquiries. Those inquiries must have failed to elicit anything further, waiting for which has been the reason of this long delay in making the announcement—a reason now removed by the discovery of this new locality and the certainty of British origin.

JOSEPH PRESTWICH.

OBITUARY.

THE PALÆONTOLOGICAL WORK OF THE LATE WILLIAM DAVIES, F.G.S.

IN Mr. William Davies, whose death we regretted to have to record last month,[1] another link between the present school and the pioneers in British Vertebrate Palæontology has been severed. His official connexion with the British Museum placed him in the midst of a circle which included Mantell, Owen, Falconer, Agassiz, Egerton, Hugh Miller, and others, at a time when they were actively engaged in prosecuting those researches which form the basis of subsequent investigation. His mind, already imbued with the scientific method and deeply interested in the problems of Natural History, was soon permanently influenced by such associations; and the result was a keenness of perception in the determination of fragmentary remains of Vertebrata that has rarely been surpassed. In this manner Mr. Davies not only became a trusted ally and adviser of the old school of investigators, but also proved himself one of the best of helpers to the later generations that have succeeded. There are few workers of the last three decades in Vertebrate Palæontology who have not been indebted to Mr. Davies at some time for advice in difficult problems, and there are many who owe much to his kindly manner and the influence of his enthusiasm.

In his influence upon others, indeed, and in the remarkable skill with which he was able to preserve and mount even the most unpromising fossils, lay Mr. Davies' chief power as a factor in the progress of Palæontology. Wanting the literary training which it was difficult for any but the rich to obtain during his early years, he usually avoided the laborious task of writing an account of his work in a suitable form for publication. His discoveries and conclusions were always at the service of those who could make best use of them; and he was never in a happier mood than when

[1] See GEOLOGICAL MAGAZINE, March, 1891, p. 144.

showing the latest novelties in the British Museum to those who could appreciate them and publish the new facts in a form that would tend to the advancement of knowledge. From 1865 onwards, however, Mr. Davies was an occasional contributor to the GEOLOGICAL MAGAZINE; and in 1886 he added a short description of the Vertebrate fossils to Dr. Henry Hicks' paper on the caves of the Vale of Clwyd in the Quarterly Journal of the Geological Society. Apart from incidental observations and letters, these contributions may be enumerated as follows:—

1865. On the Preservation of Fossil Mammalian Remains found in Tertiary Deposits, GEOL. MAG. Vol. II. pp. 239, 240.
1871. Alphabetical Catalogue of Type Specimens of Fossil Fishes in the British Museum, *ibid.* Vol. VIII. pp. 208–216, 334.
1872. On the Rostral Prolongations of *Squaloraia polyspondyla*, Ag., *ibid.* Vol. IX. pp. 145–150, Pl. IV.
1874. (With H. Woodward.) Notes on the Pleistocene Deposits yielding Mammalian Remains in the Vicinity of Ilford, Essex, *ibid.* Dec. II. Vol. I. pp. 390–398.
1876. On the Exhumation and Development of a large Reptile (*Omosaurus armatus*, Owen), from the Kimmeridge Clay, Swindon, *ibid.* Dec. II. Vol. III. pp. 193–197, Pls. VII. VIII.
1878. On a Collection of Pleistocene Mammals Dredged off the Eastern Coast, *ibid.* Dec. II. Vol. V. pp. 97–100.
1878. On the Nomenclature of *Saurocephalus lanciformis* of the British Cretaceous Deposits; with Description of a New Species (*S. Woodwardii*), *ibid.* Dec. II. Vol. V. pp. 254–261, Pl. VIII.
1879. On some Fish Exuviæ from the Chalk, generally referred to *Dercetis elongatus*, Ag.; and on a New Species of Fossil Annelide, *Terebella Lewesiensis*, *ibid.* Dec. II. Vol. VI. pp. 145–148.
1879. On some Recently Discovered Teeth of *Ovibos moschatus* from Crayford, Kent, *ibid.* Dec. II. Vol. VI. pp. 246–248.
1880. On some Fossil Bird-Remains from the Siwalik Hills in the British Museum, *ibid.* Dec. II. Vol. VII. pp. 18–27, Pl. II.
1880. On some Bones of the Lynx from Teesdale, obtained by Mr. James Backhouse, of York, *ibid.* Dec. II. Vol. VII. pp. 346–349, Pls. XI. XII.
1884. Note on Remains of the Emu from the Wellington Caves, New South Wales, *ibid.* Dec. III. Vol. I. p. 265.
1884. Note on some New Carnivores from the British Eocene Formations, *ibid.* Dec. III. Vol. I. pp. 433–438, Pl. XIV.
1886. Note on the Animal Remains from some Bone-Caves in North Wales (Ffynnon Beuno and Cae Gwyn), Quart. Journ. Geol. Soc. vol. xlii. pp. 17–19.
1887. On New Species of *Pholidophorus* from the Purbeck Beds of Dorsetshire, GEOL. MAG. Dec. III. Vol. IV. pp. 337–339, Pl. X.

Mr. Davies' long association with Sir Antonio Brady in recovering the remains of fossil Mammalia from the brick-fields near Ilford, resulted in 1874 in the publication of "A Catalogue of the Pleistocene Vertebrata in the Collection of Sir Antonio Brady," which is of great value on account of its well-known accuracy. This was the only separate publication he undertook as author, though by no means the only one in the preparation of which he played an important part. In Fossil Fishes, Prof. L. G. de Koninck acknowledges Mr. Davies' important aid when preparing the first part of the "Faune Calc. Carbonif. Belgique"; and the author of the first two volumes of the British Museum Catalogue of Fossil Fishes expresses his indebtedness to Mr. Davies, not only for much advice, but also for his revision of the whole of the proof-sheets. Notwith-

standing his previous retirement from active service, Mr. Davies also undertook the revision of the proofs of the British Museum Catalogue of Fossil Reptiles. As Sir Richard Owen remarks, the discovery of the cranium of *Dasornis* was due to Mr. Davies, who recognized it among some fish-remains from the London Clay; and to the skilled manipulation of the same observer we are indebted for the well-displayed jaws of *Odontopteryx*. Prof. Leith Adams was in continual communication and consultation with Mr. Davies while preparing his Memoir on British Fossil Elephants, of the dentition of which our lamented friend had unrivalled knowledge; and the British Museum Catalogue of Fossil Mammalia owes much of its value as a record of the history of specimens to its careful revision by the same hand. Only a little more than a year ago, Mr. Davies entered with his usual enthusiasm upon the reading of the proofs of Messrs. Woodward and Sherborn's "Catalogue of British Fossil Vertebrata," to which he made important contributions; and several of his letters, containing information of much historical value in reference to literature and specimens, are now preserved in a bound volume in the Geological Library of the British Museum.

Apart from all literary work, however, Mr. William Davies leaves some enduring monuments in the British Museum. The great head of the Ilford Mammoth was rescued from destruction entirely by his skill in the disinterment of such remains; and the same remark applies to many of the unique gems in the Brady Collection. The bones of the huge *Omosaurus* from the Kimmeridge Clay of Swindon were extricated from a difficult matrix, or built up from apparently worthless fragments, in part by his own hand, in part under his direction. *Hyperodapedon*—one of the latest acquisitions—was worked out by the masons under the same supervision; and Mr. Davies played no unimportant part in superintending the extrication from the matrix of some of the finest examples of Siwalik Mammals and South African Reptiles. Palæontology has, indeed, lost a master-hand.

A. S. W.

MISCELLANEOUS.

The International Geological Congress, Washington, 26th August, 1891.

The negociations respecting the proposed change in the date and locality of the next meeting of the International Geological Congress were at length brought to a conclusion by the American Organizing Committee. It has now been decided that the Congress shall be held in Washington during the week commencing Wednesday 26th August, 1891. Sub-committees have been formed to arrange for the scientific business, the long excursions, the local arrangements, and for the nomination of officers. A circular has been issued announcing the proposed arrangements, and cordially inviting all Geologists to take part in the labours of the Congress.